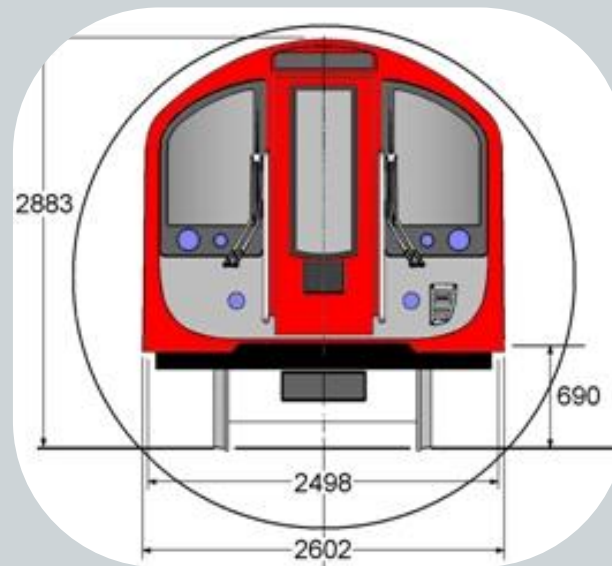


21 June 2016

Reducing Dwell Time: London Underground Central Line

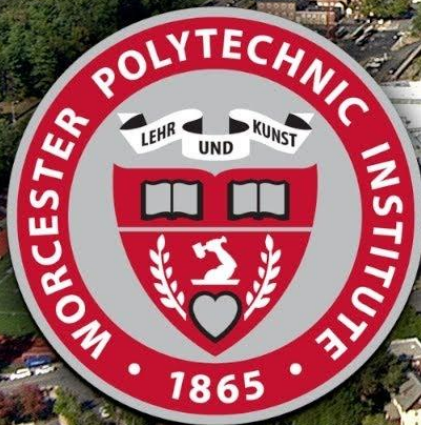


JAKE KELLEY ♦ DANNY KO
LAURIE MAZZA ♦ SAMANTHA ROBINSON

Presentation Introduction



AN INTRO TO THE PRESENTERS AND PRESENTATION



WPI

Meet the Team



Jake Kelley

Home:
Massachusetts

Major:
Mechanical
Engineering
(Mechanical Design)



Danny Ko

Home: South Korea,
Colorado

Major:
Aerospace
Engineering
(Astronautics)



Laurie Mazza

Home: Rhode Island

Majors: Computer
Science and
Interactive Media &
Game Development
(Visual Arts)



Sam Robinson

Home: Pennsylvania

Major:
Mechanical
Engineering
(Mechanical Design)



Presentation Outline

○ Introduction

○ Background

- Project Goal & Objectives

○ Identify Factors

- Station Observation

- Initial Employee Interviews

- Train Observation

○ Determine Key Factors

- CCTV Observation

- Passenger Survey

- Frontline Employee Interviews

○ Propose Solutions

- Station Platforms

- Display of Information

- Employees

- Rolling Stock

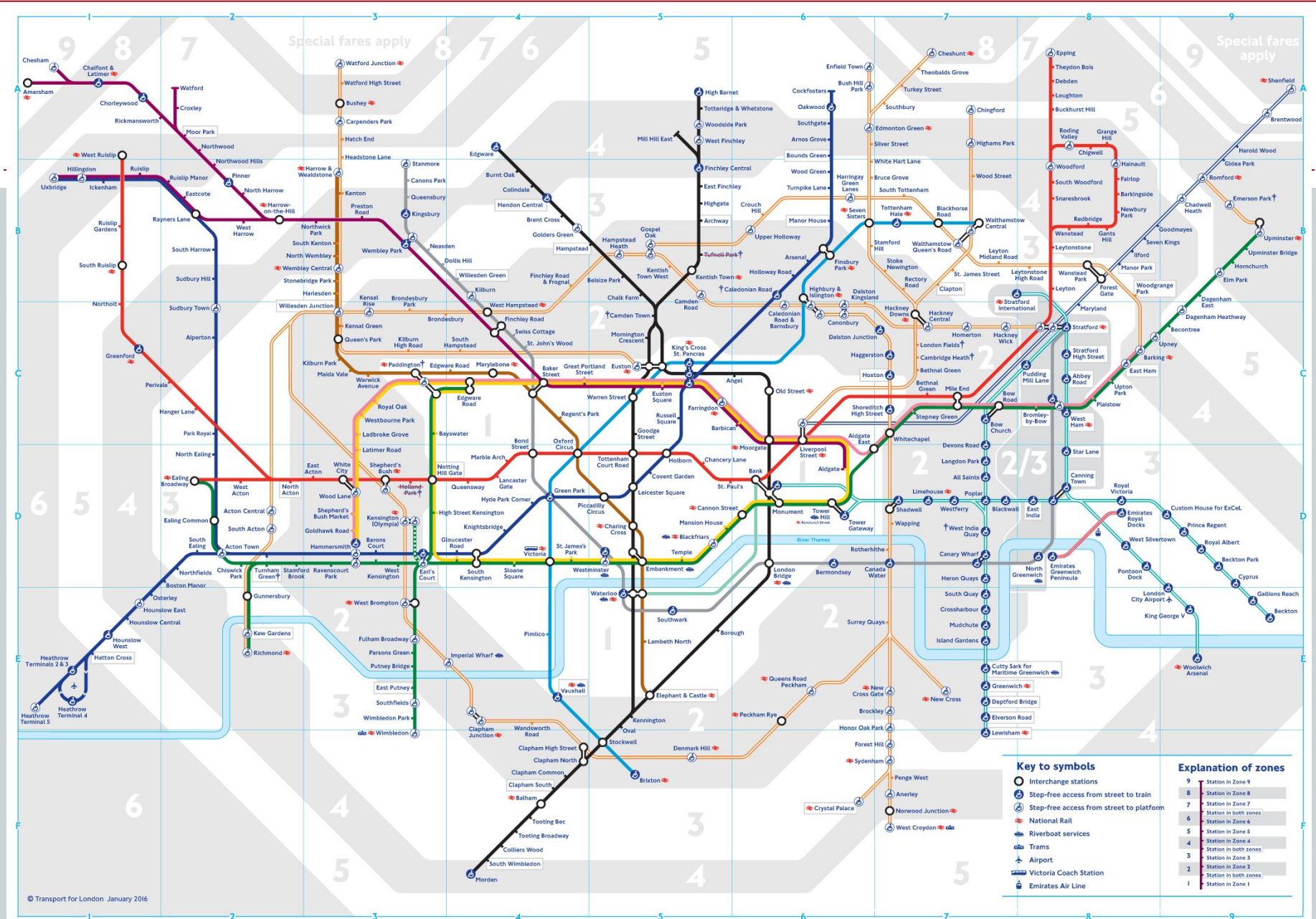
○ Recommendations

Nature of the Problem



A BRIEF BACKGROUND OVERVIEW





Key to symbols

- Interchange stations
- Step-free access from street to train
- Step-free access from street to platform
- National Rail
- Riverboat services
- Trams
- Airport
- Victoria Coach Station
- Emirates Air Line

Explanation of zones

- Station in Zone 9
- Station in Zone 8
- Station in Zone 7
- Station in both zones
- Station in Zone 6
- Station in Zone 5
- Station in Zone 4
- Station in both zones
- Station in Zone 3
- Station in Zone 2
- Station in both zones
- Station in Zone 1

Central Line



Central Line Problems

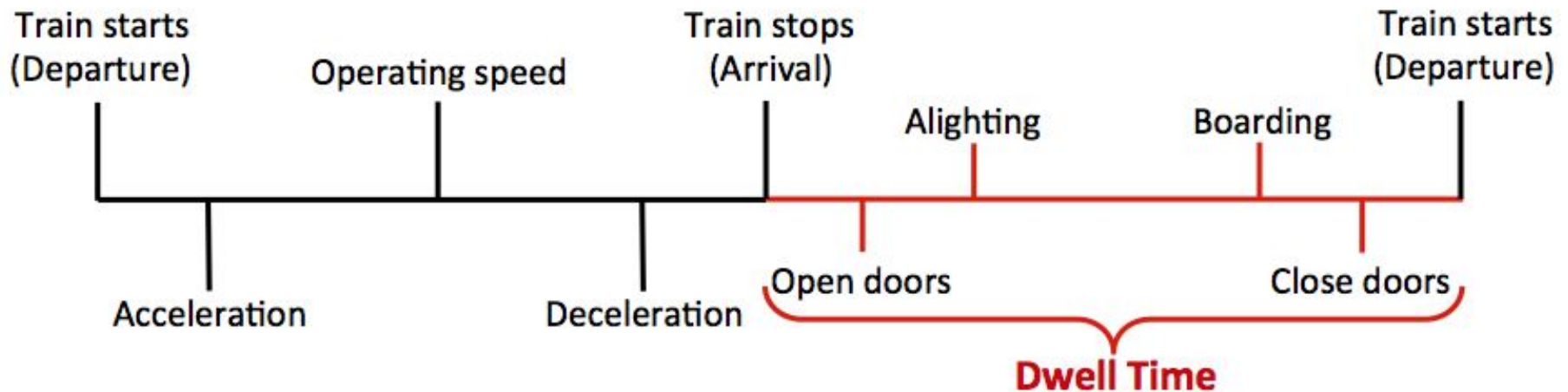


Third highest average
excess journey time

Highest average total lost
customer hours

Delays due to overcrowding

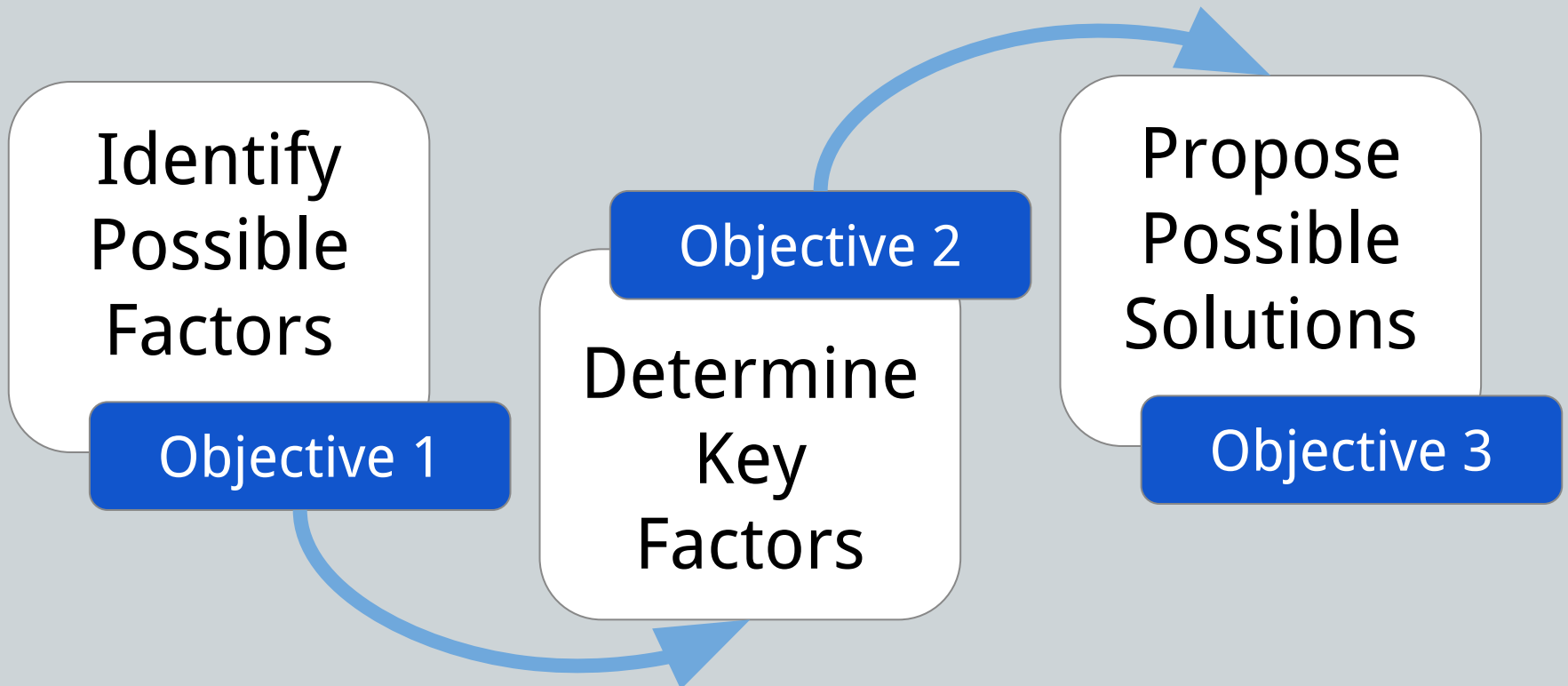
Delays & Dwell Time



Project Objectives



**Form solutions to minimize high dwell times
in the Central Line**





Objective	Task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Identify Factors	Initial Employee Interviews							
	Station Observation & Station Index							
	Train Observation							
Determine Key Factors	CCTV Observation							
	Passenger Survey							
	Final Employee Interviews							
Propose Solutions	Analyze Data							
	Form Solutions							
	Finalize Report							

Identifying Possible Factors



OBJECTIVE 1 OVERVIEW

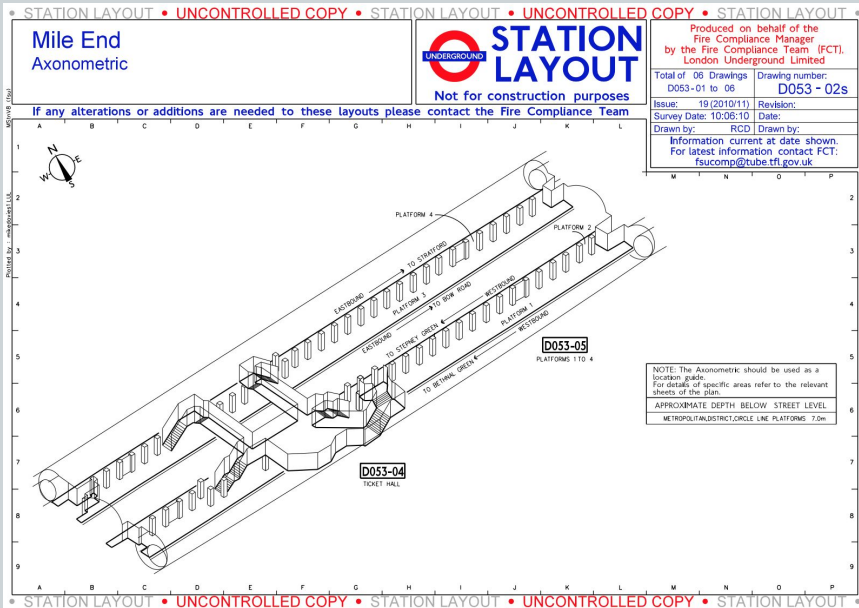


Employee
Interviews

Station
Observation

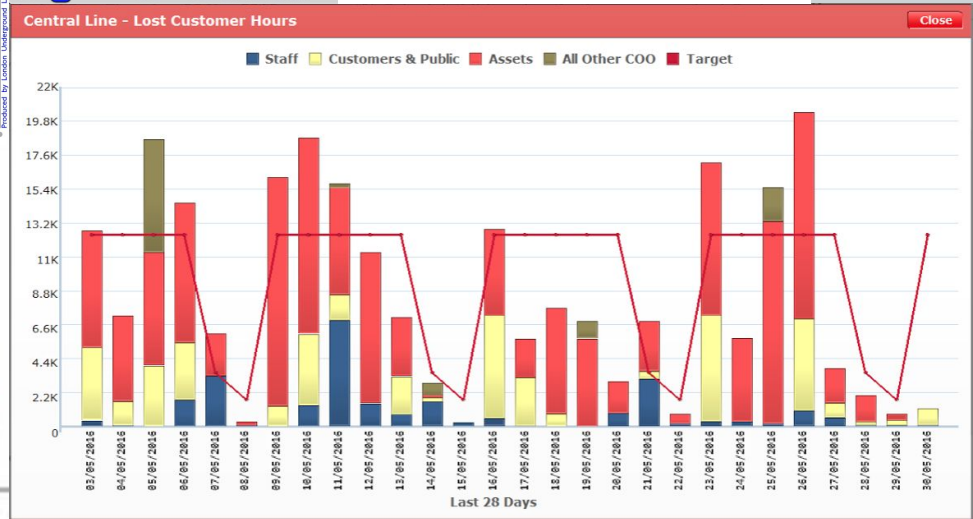
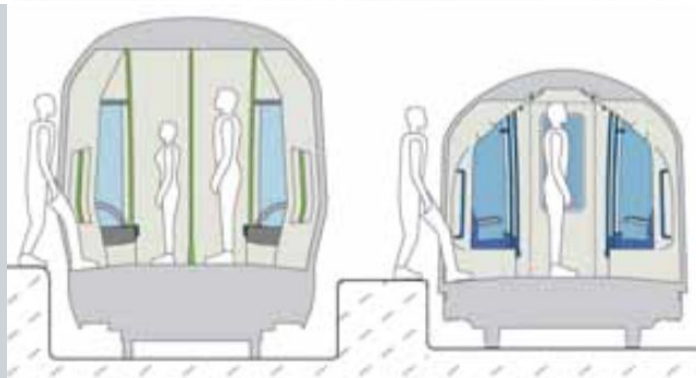
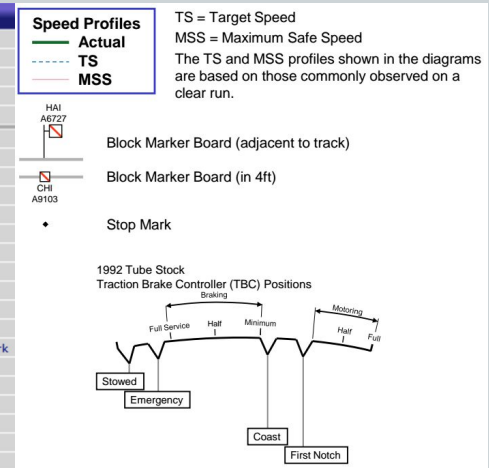
Train
Observation

Interviews: Behind the Scenes



Colour coded Train Legend

Emergency or Uncommon Destinations	Special Trains	No Train Destination - Line Default Applied	No Train Destination, No Train Information	All Other Line's Trains
WB : --- EAB Ealing Broadway	WB : --- LES Leytonstone	WB : --- NOA North Acton	WB : --- NOR Northolt	WB : --- RUG Ruislip Gardens
WB : --- WER West Ruislip	WB : --- WCT White City	WB : --- WFD Woodford	EB : --- DEB Debden	EB : --- EPP Epping
EB : --- HAI Hainault	EB : --- HAI Hainault via Newbury Park	EB : --- LES Leytonstone	EB : --- LTN Loughton	EB : --- NEP Newbury Park
EB : --- WCT White City	EB : --- WFD Woodford	EB : --- WFD Woodford via Hainault		

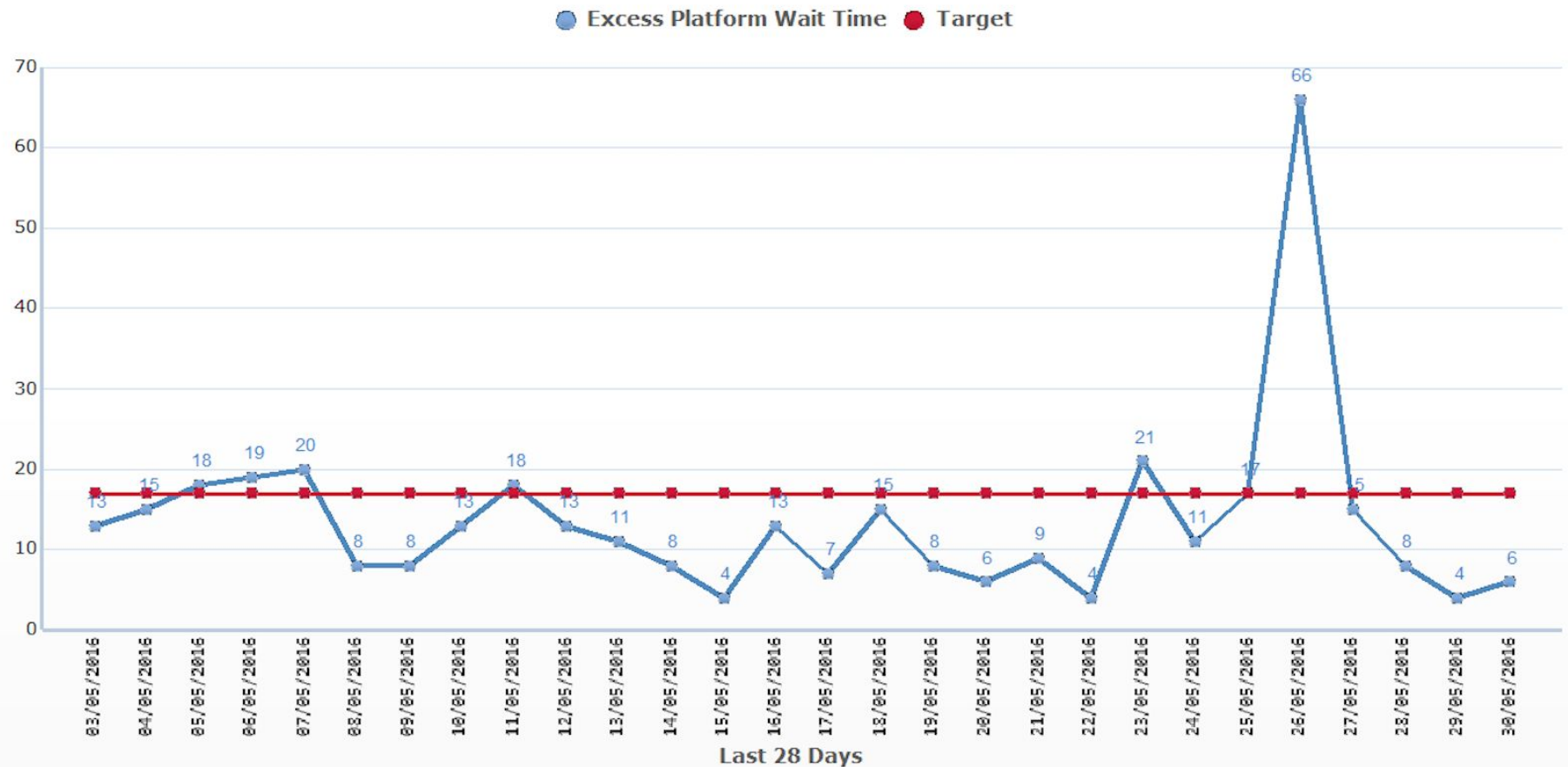


Interviews: Behind the Scenes



Central Line - Excess Platform Wait Time

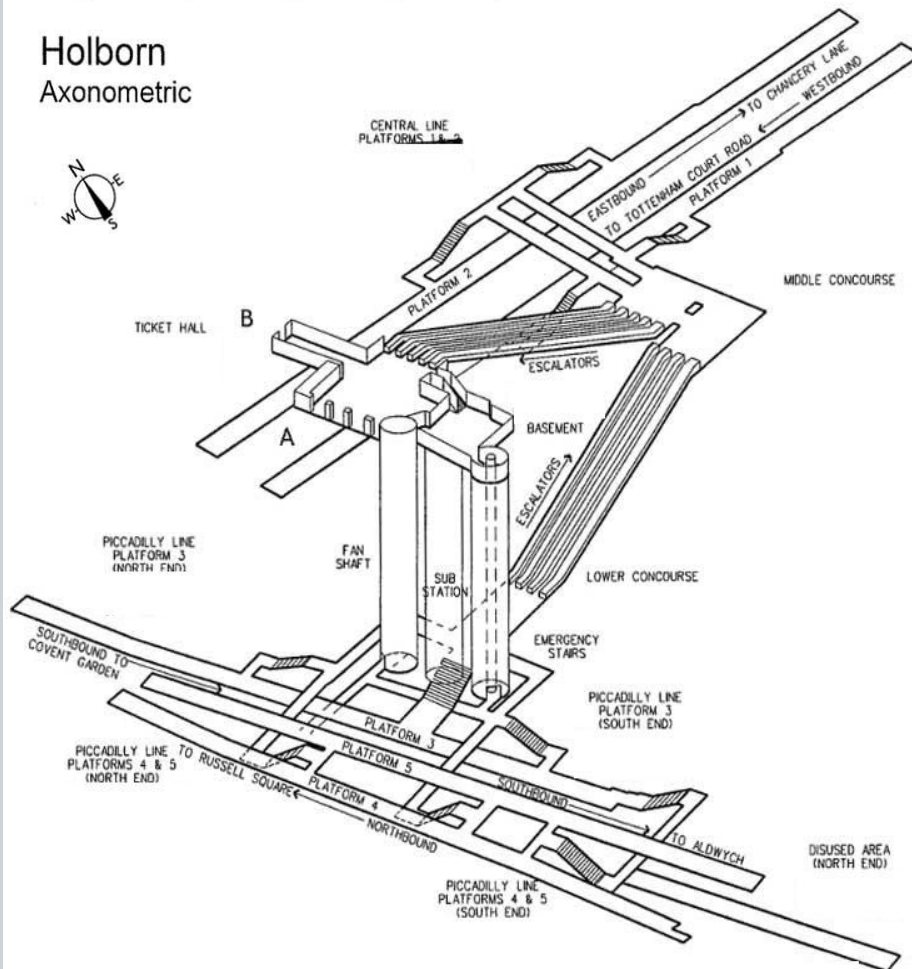
Close



Station Observation



Holborn
Axonometric



Station Name

Time observed

Station Layout

Platform Layout

Information Display

Passenger Notes

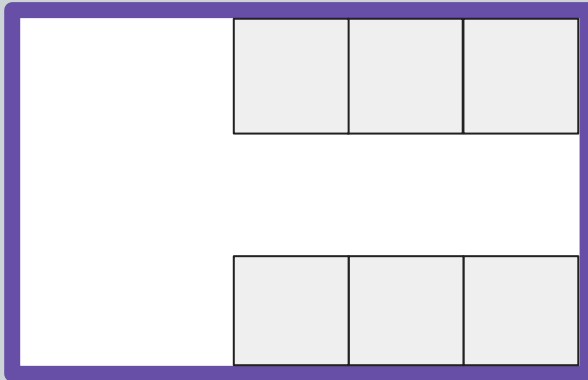
Train Crowd. Levels

Dwell Times

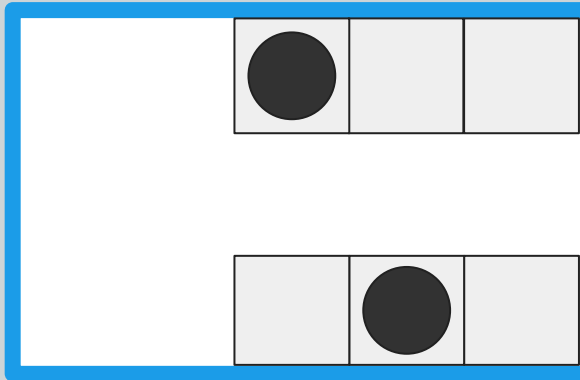
Train Crowdedness Level (TCL)



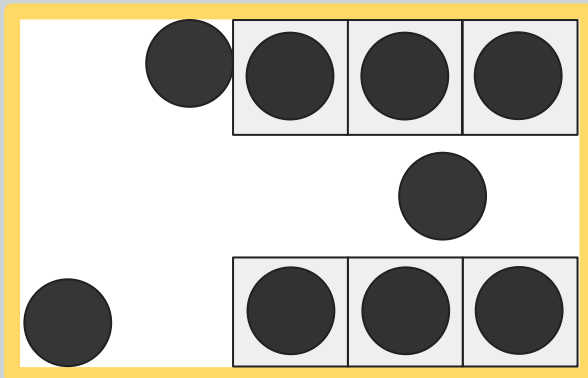
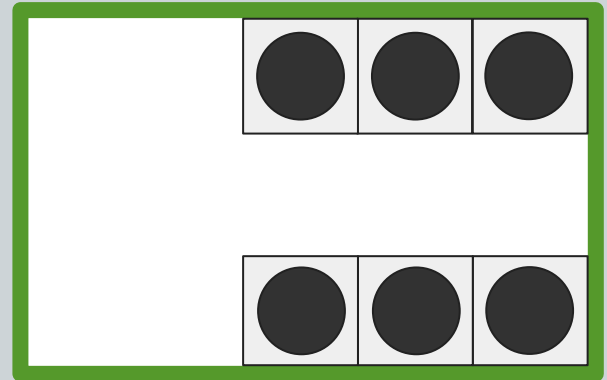
0 = empty train



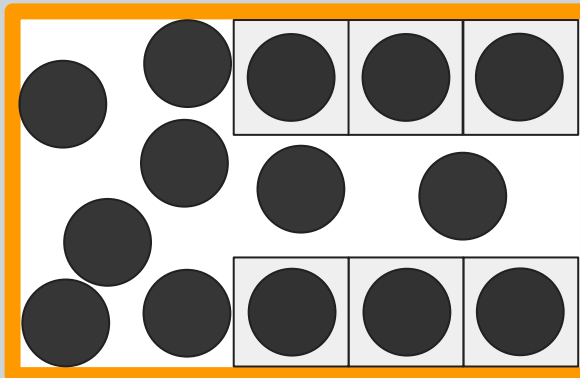
1 = some seats taken



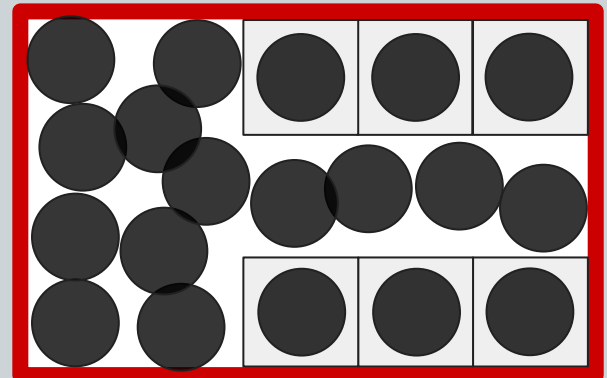
2 = all seats taken



3 = all seats and some standing room taken

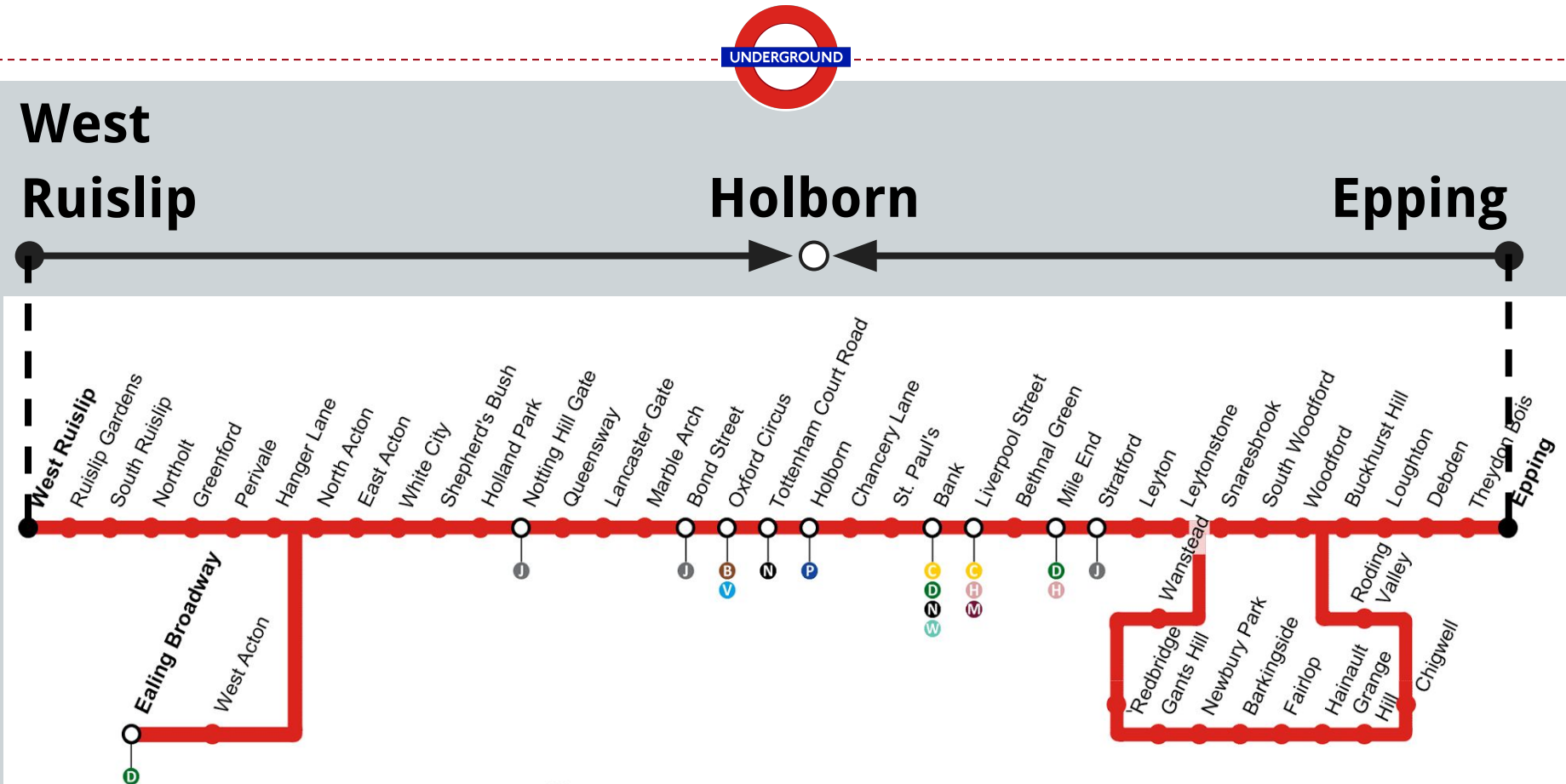


4 = all seats and most standing room taken



5 = all seats and standing room taken

Train Observation

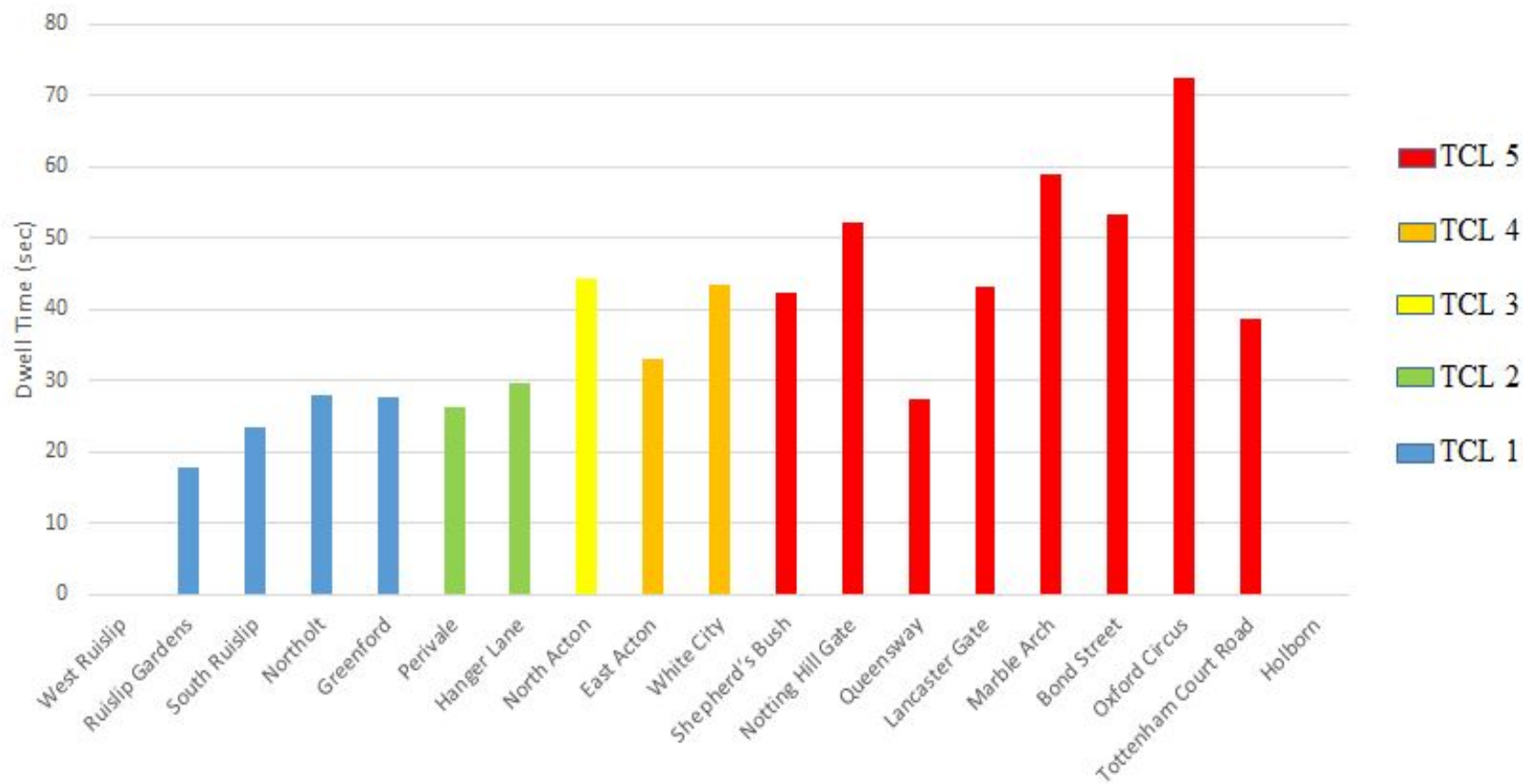


Note: Dwell Time TCL Passenger Flow

Train Observation



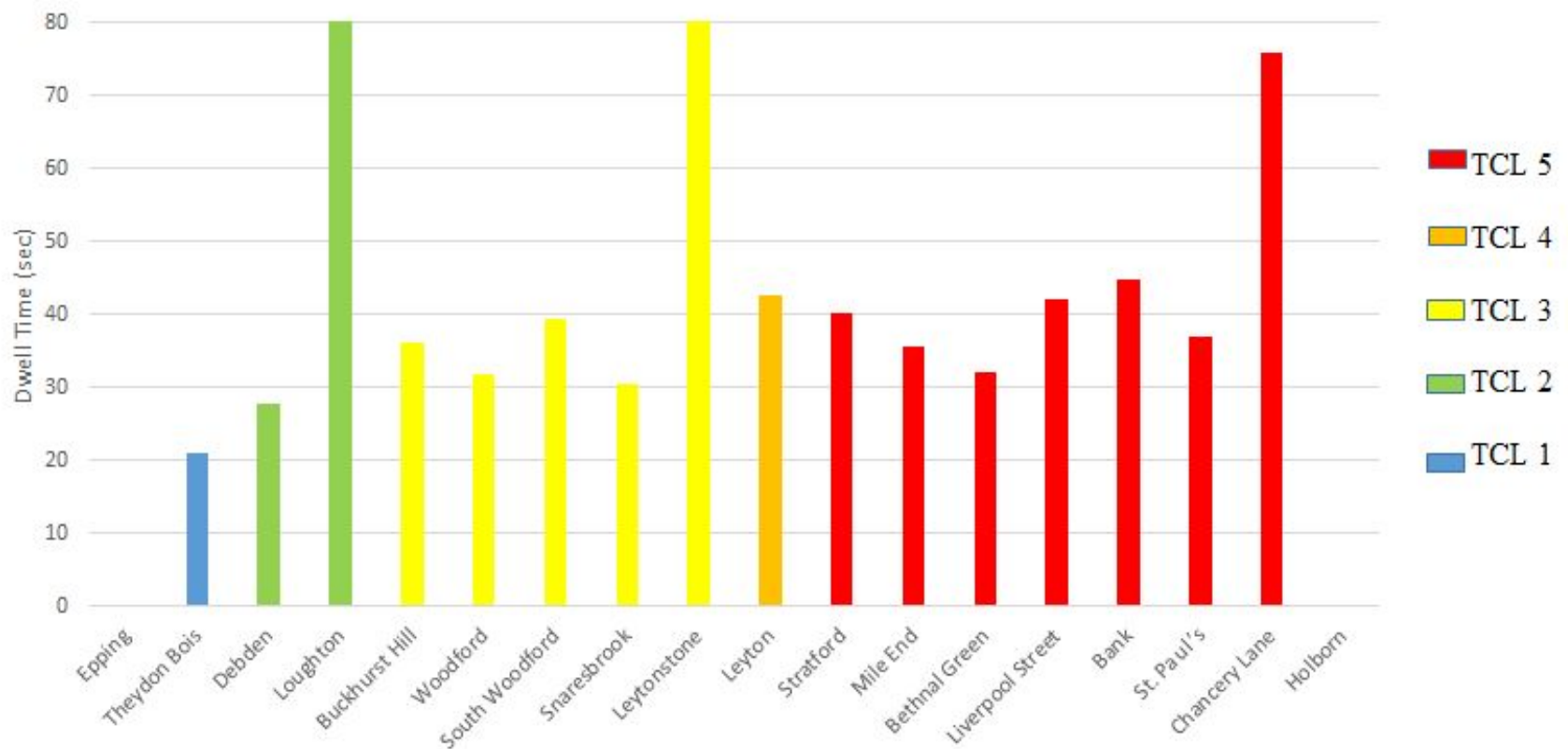
Dwell Time and Train Crowdedness Level Per Eastbound Platforms



Train Observation



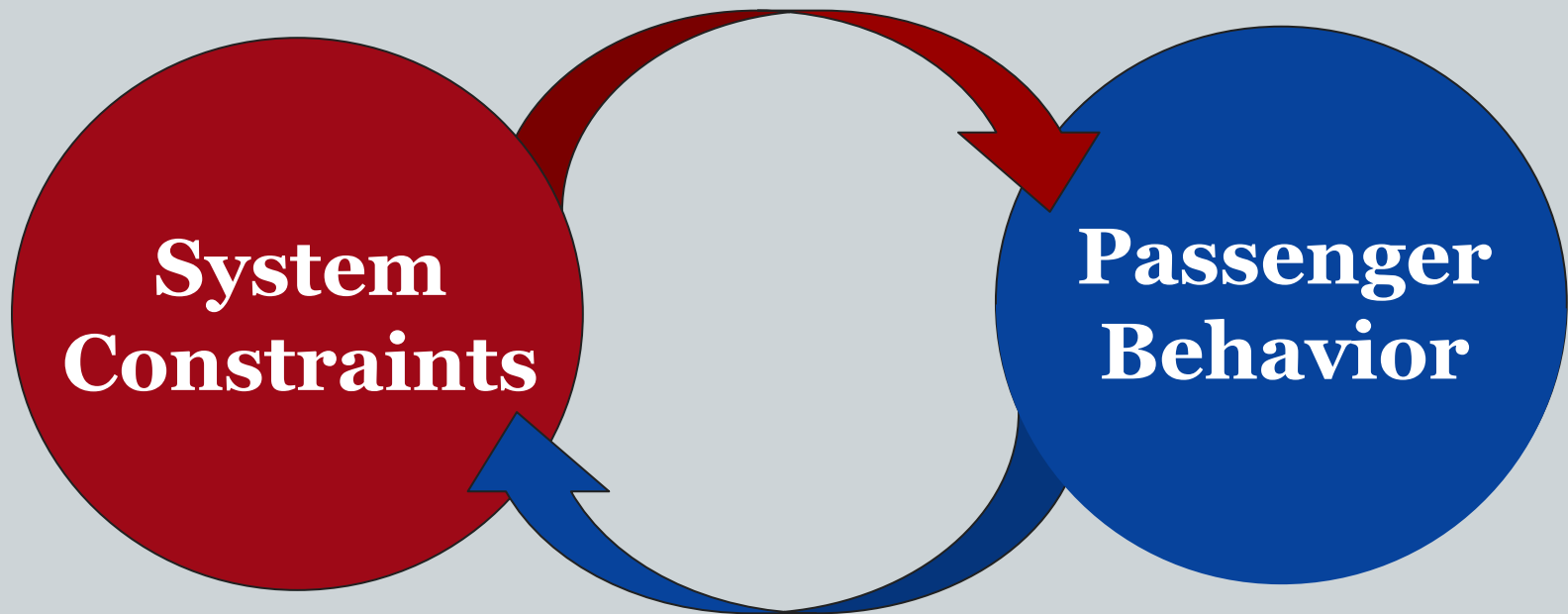
Dwell Time and Train Crowdedness Level Per Westbound Platforms



*note: Loughton and Leytonstone are caused by delays in the line, not passenger behavior

OBJECTIVE 1

Identify Possible Factors



Passenger Behavior Factors



Station
Passenger Flow

Platform
Passenger Flow

Alighting &
Boarding

Door Reopening

Luggage

Train Car
Passenger Flow

Commuters

Shoppers

Tourists

System Constraint Factors



Station Layout

Platform Layout

Signalling
System

Tunnels

Rolling Stock

Employees

Announcements

Signage

Maps

Determining Key Factors



OBJECTIVE 2 OVERVIEW

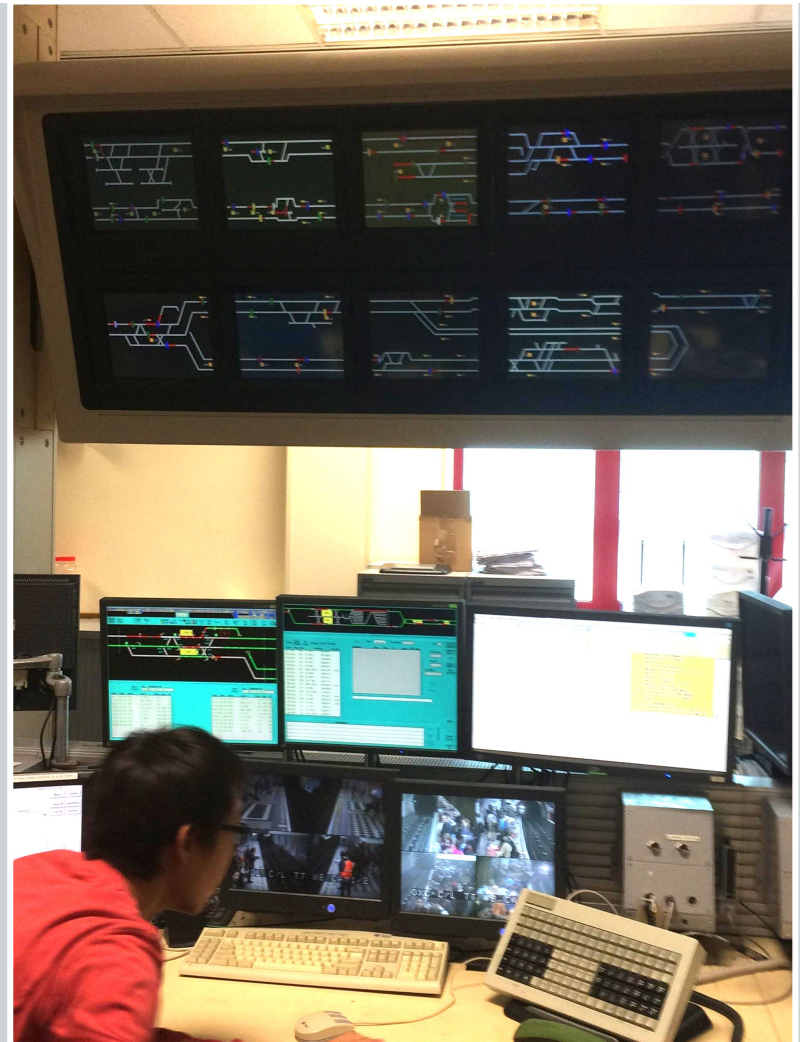


CCTV
Observation

Passenger
Survey

Employee
Interviews

CCTV Observation



CCTV Observation



Average
Dwell Time

Large Items

Types of
Passengers

Average Platform
Crowdedness Level

Door Reopening
Accidental & Intentional

Average Dwell times	PCL (front)	PCL (middle -front)	PCL (middle -back)	PCL (back)	Walking Support Items	Large Luggage	Accidental door reopening	Intentional door reopening	Type: rushing/ in a hurry	Type: oblivious/ obstructing	Type: groups/ chatting	Ap a
29.32	0.6	0.9	0.4	1.1	1	1	0	0	3	1	1	
31.37	1.1	2.6	2.5	3.5	1	3	1	0	11	4	0	
35.36	4.1	3.2	1.9	1.1	1	2	0	0	18	4	1	
37.53	2.9	3.8	3.6	2.7	1	14	2	3	31	2	0	
31.25	0.8	0.7	0.8	1.4	0	0	0	0	8	0	0	
31.79	0.5	2.6	2.6	2	1	3	0	1	6	0	0	
31.85	0.7	1	1.3	1.2	0	3	1	0	11	0	0	
37.33	1.5	2.2	2.1	2.2	1	2	1	5	11	1	1	

Platform Crowdedness Level (PCL)



0

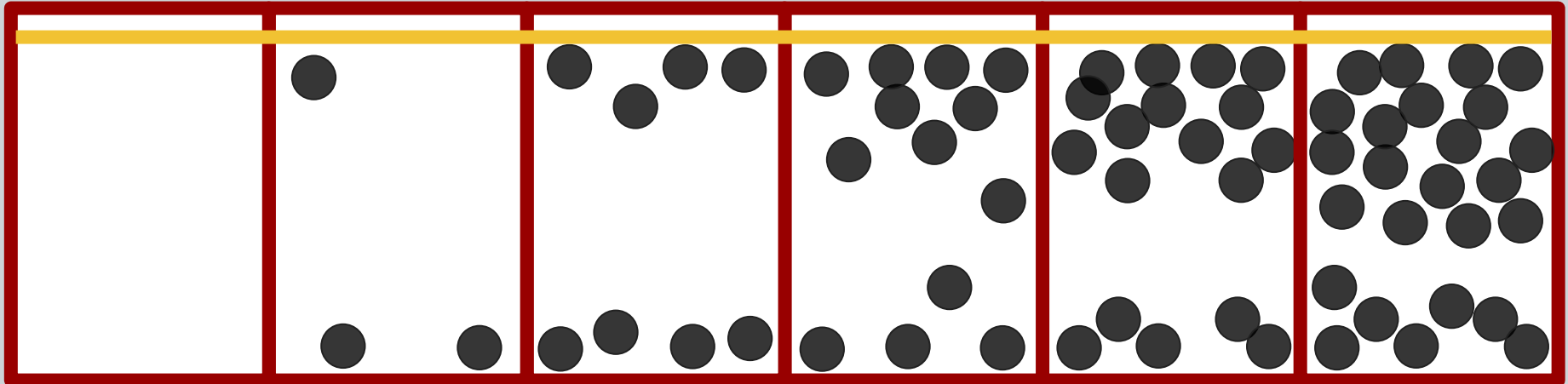
1

2

3

4

5



0

1-5

5-10

11-15

16-20

21+

passengers

passengers

passengers

passengers

passengers

passengers

CCTV Observation



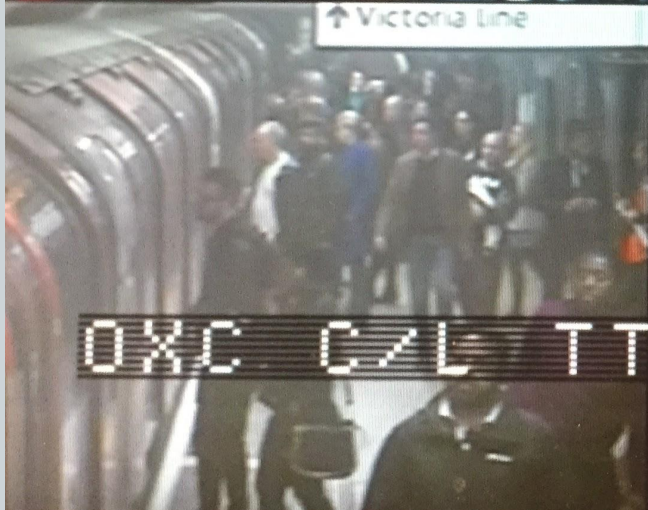
5



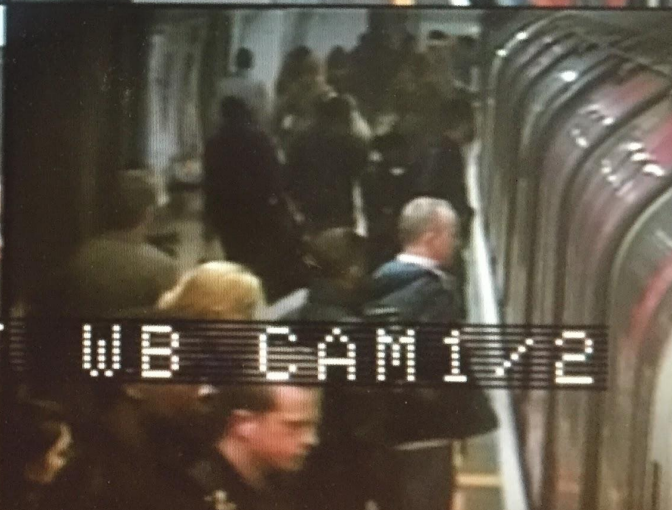
2



4



3



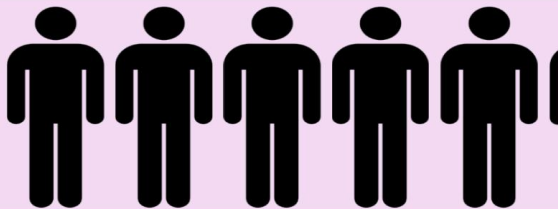
Problem Passengers per 10 Trains



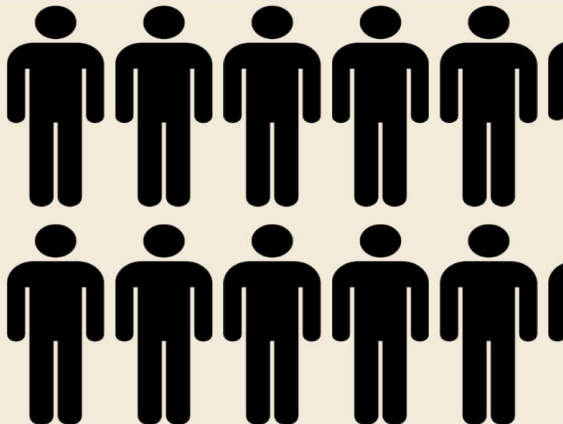
0.8 Groups:
Families & Friends



1.3 Obstructing:
Oblivious & Confused



5.1 W/Luggage:
Larger than Backpack



11.2 Rushing:
Last second
boarders

Passenger Survey



100%

What is your primary reason for using the Central Line?

- ☐ Commuting
- ☐ Tourism
- ☐ Shopping
- ☒ Casual

If possible, do you typically run onto trains last minute?

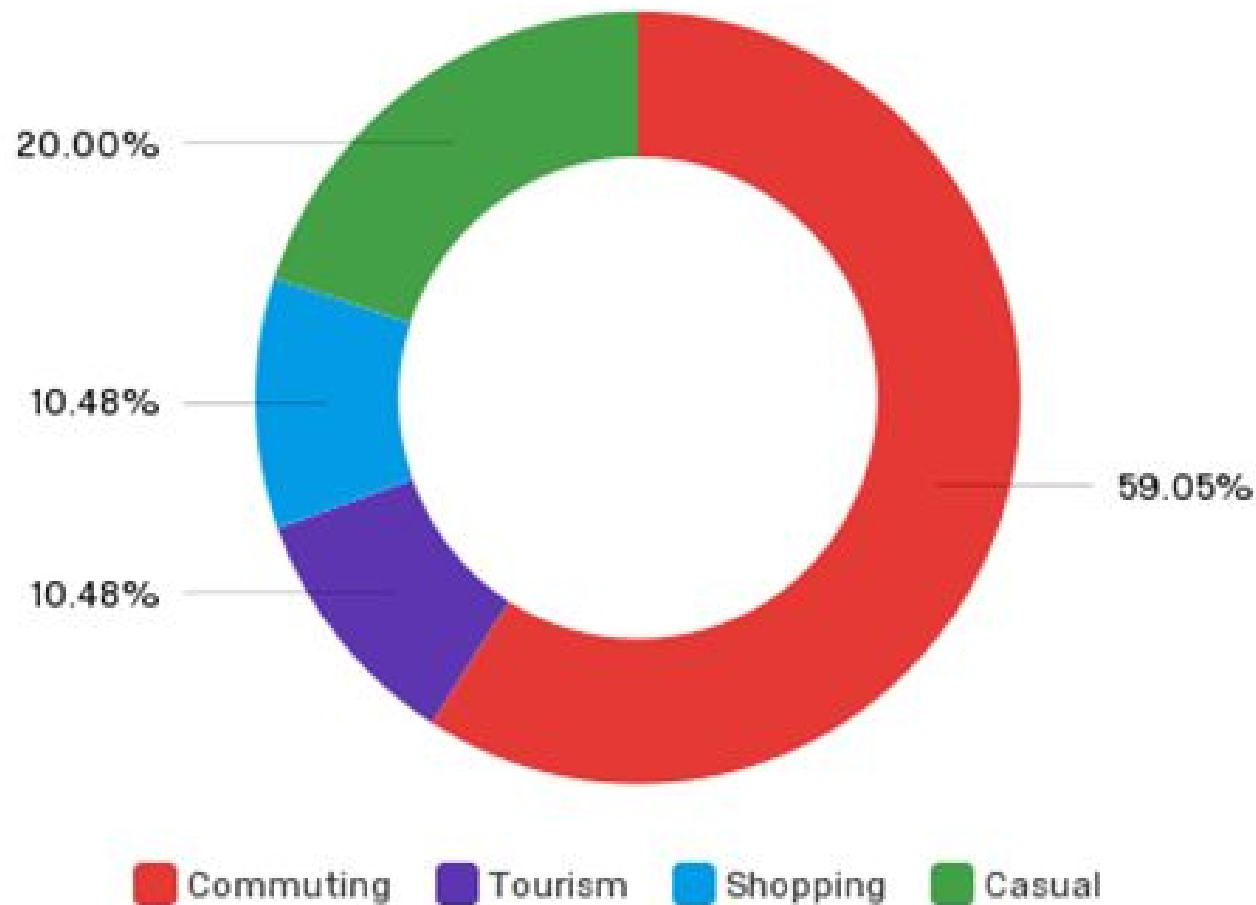
- ☐ Yes
- ☒ No
- ☐ I am not sure

If you knew that a later train is more empty than the next train, would you be willing to wait?

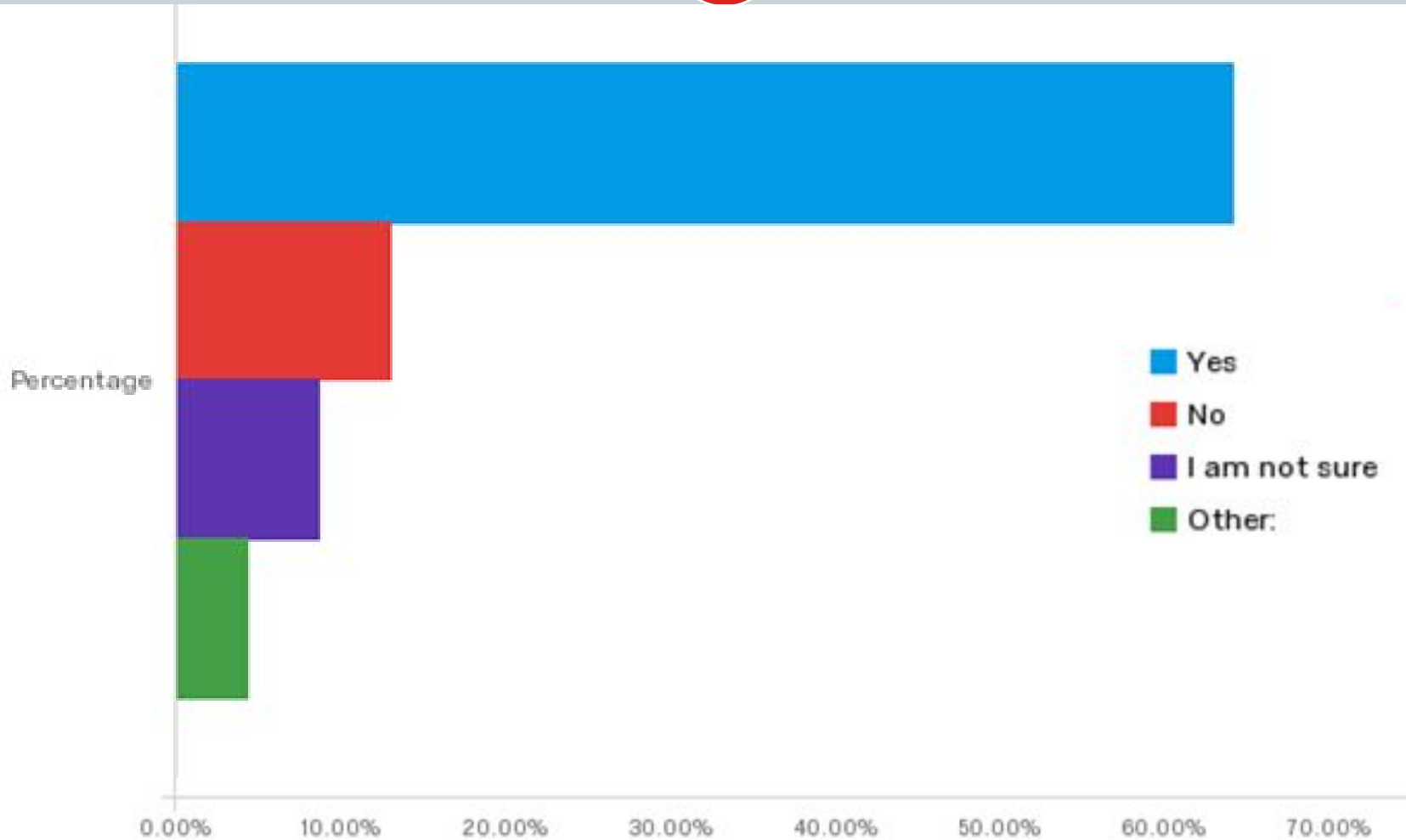
- ☐ Yes



Respondent Types



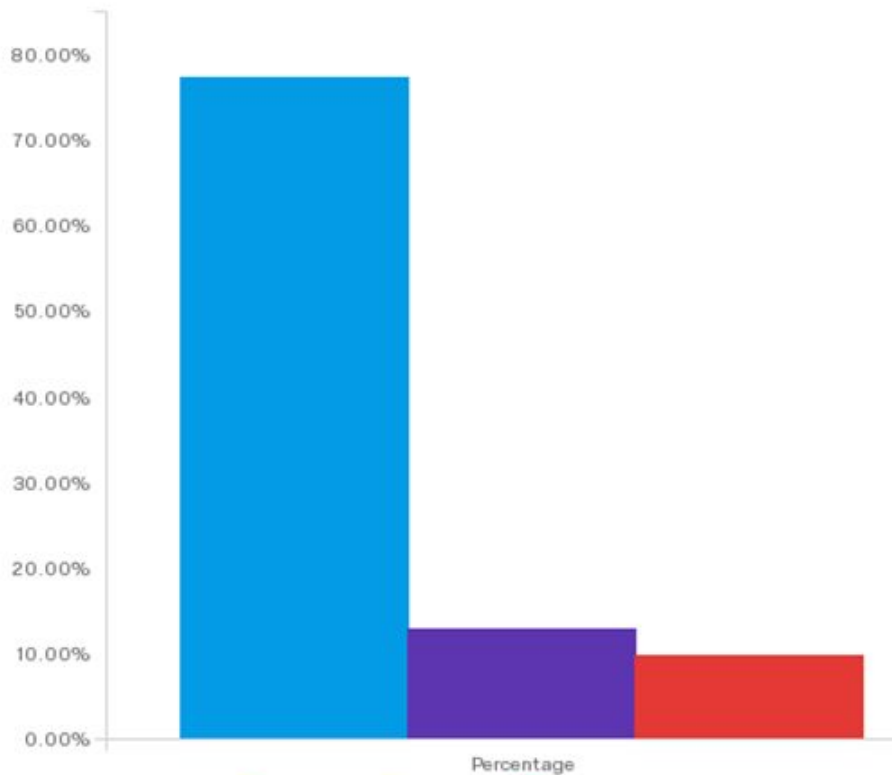
Willingness to Wait



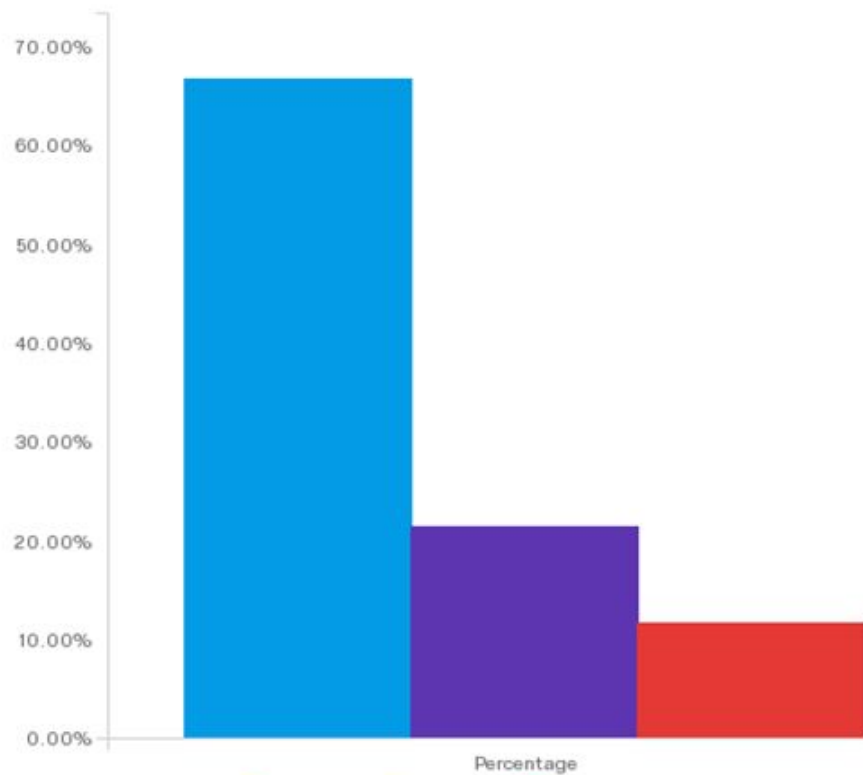
Passenger Satisfaction



Provision of Information



Platform Layout

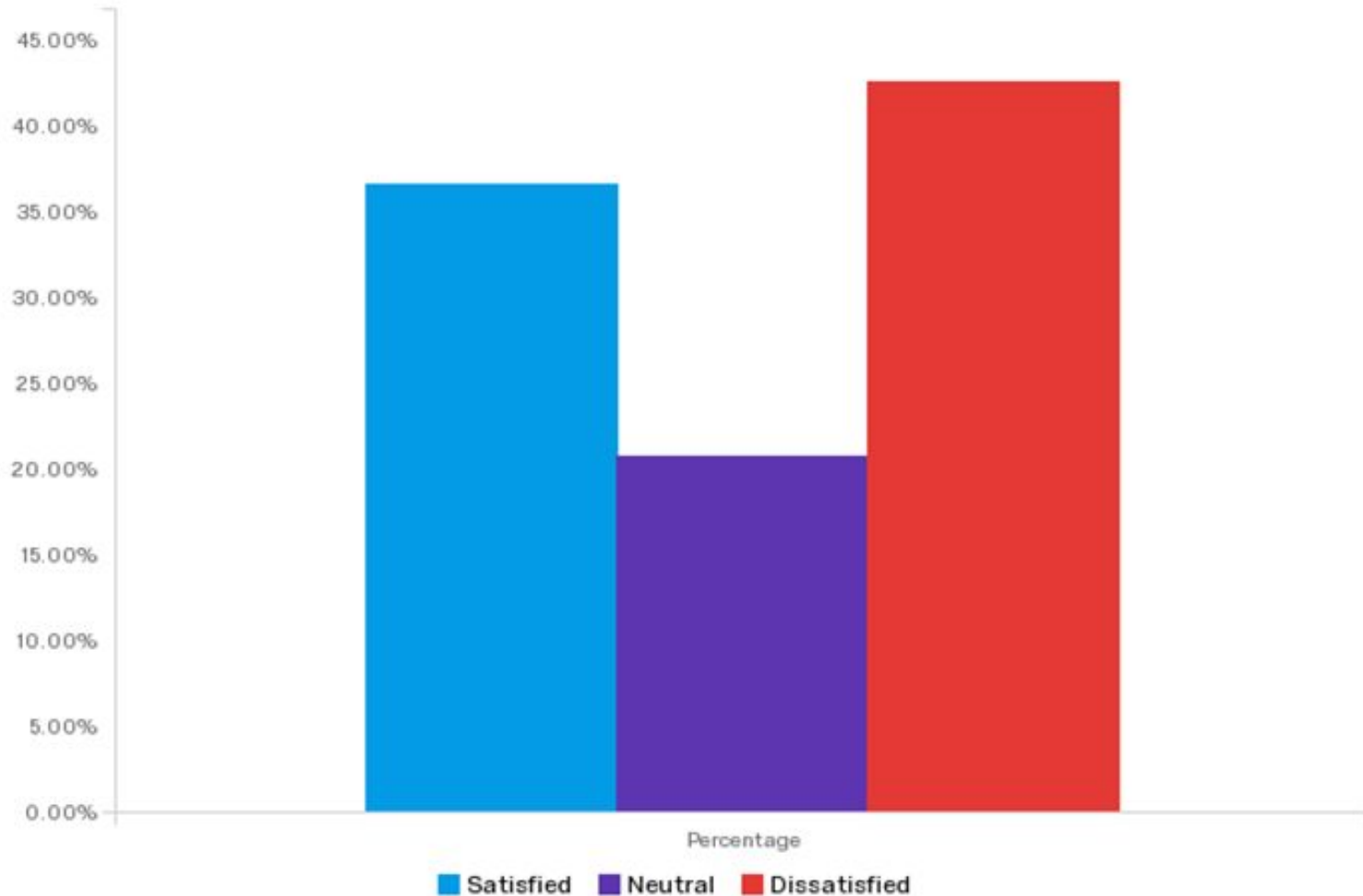


■ Satisfied ■ Neutral ■ Dissatisfied

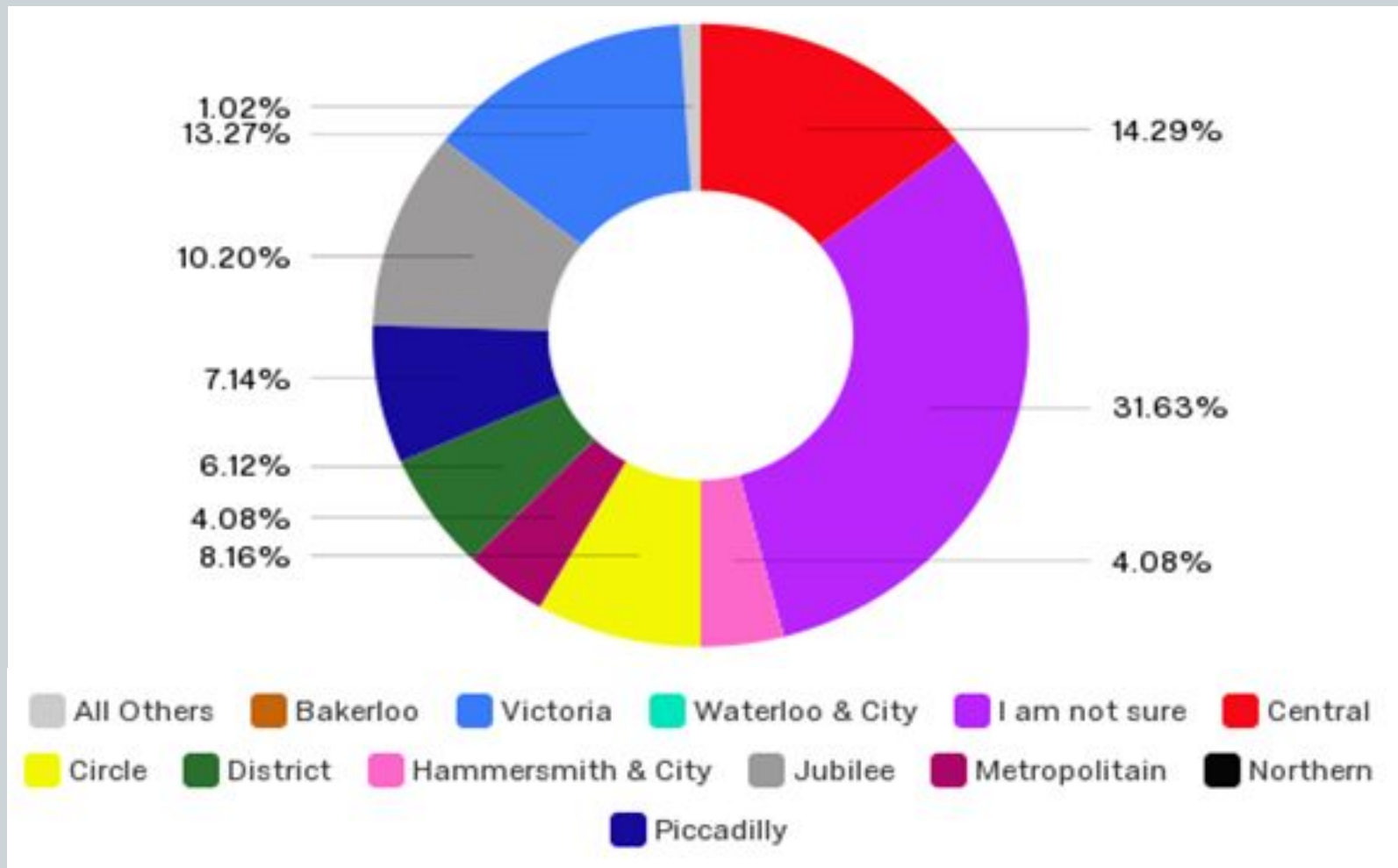
Satisfaction with Carrying Capacity



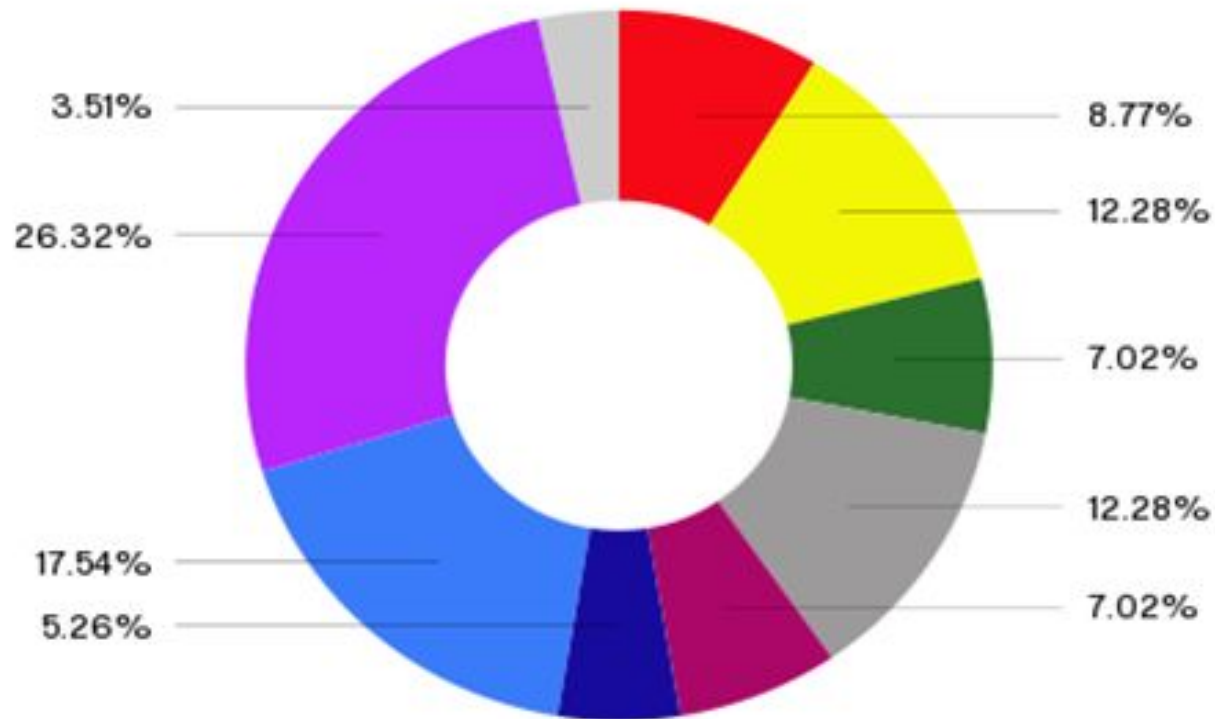
Passenger Satisfaction with Train Size and Passenger Capacity



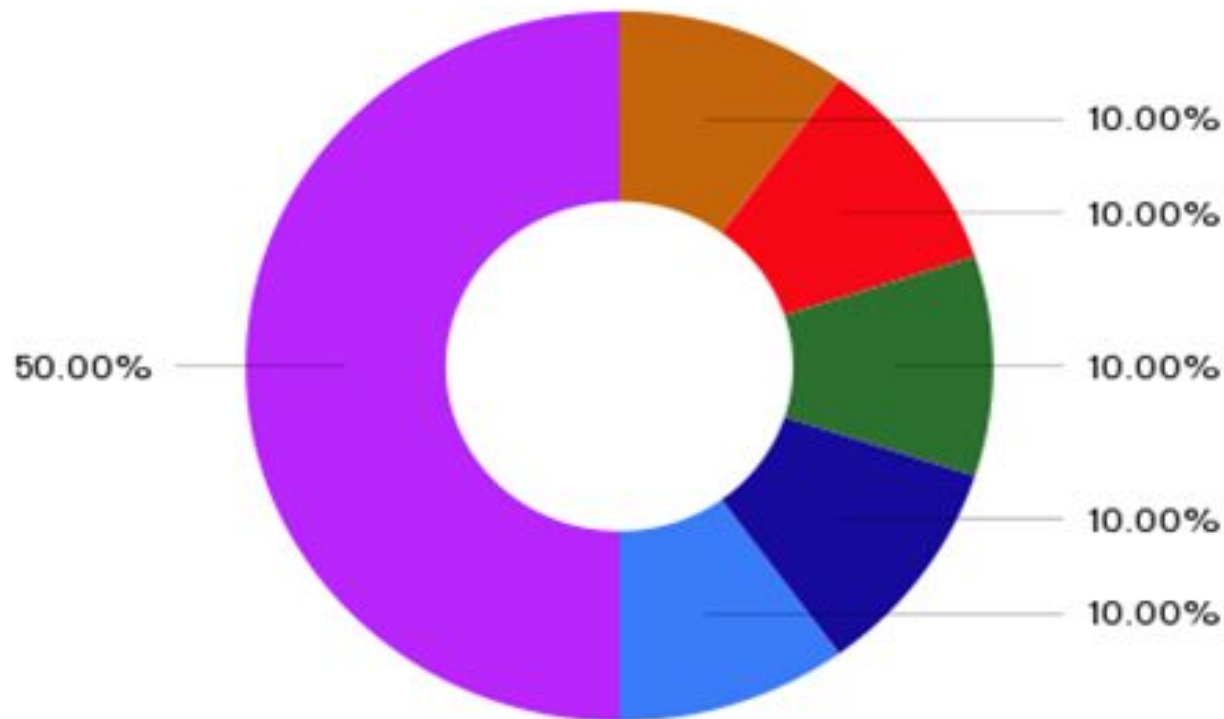
Passengers' Favorite Lines



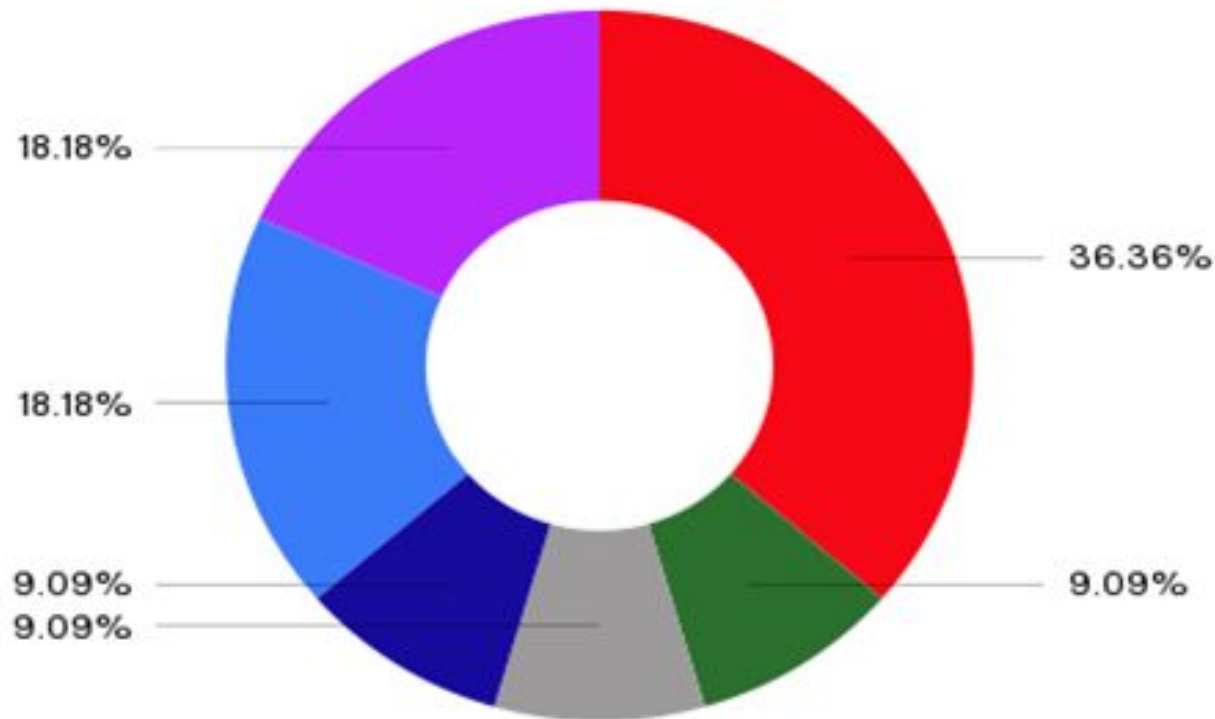
Commuters' Favorite Lines



Tourists' Favorite Lines



Shoppers' Favorite Lines



Casual Riders' Favorite Lines



Interviews: Frontline



Problem Areas

- Rushers
- Groups
- Platform crowding

Solutions

- Upgrade trains
- **More platform attendants**

OBJECTIVE 2

Determine Key Factors



**Uneven
Platform
Crowding**

**Obstructed
Boarding &
Alighting**

PCL vs Platform Entrance/Exit

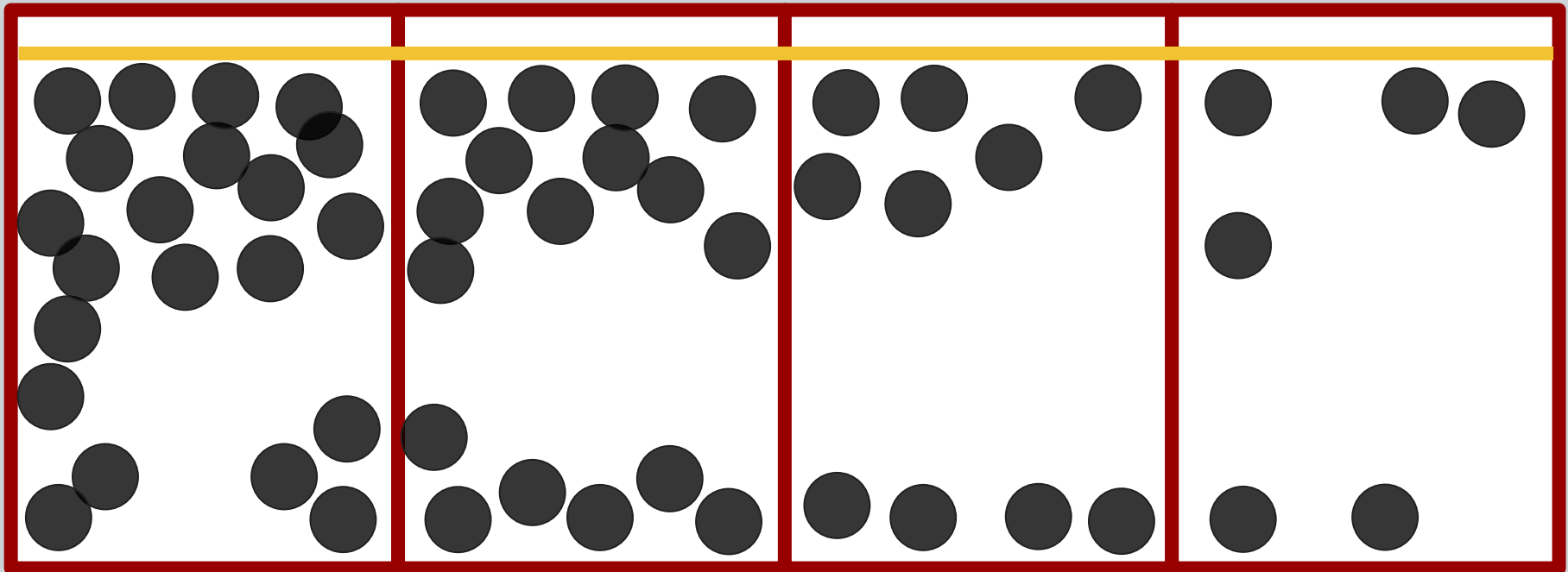


4.1

3.2

1.9

1.1



Front

F-Mid

B-Mid

Back

Key Factor: Uneven Platform Crowding



Platform Crowding
at Entrances/Exits

Problem
Passengers

Provision of
Information

Station
Platforms

Key Factor: Boarding & Alighting Issues



Obstructed
Boarding &
Alighting

Problem
Passengers

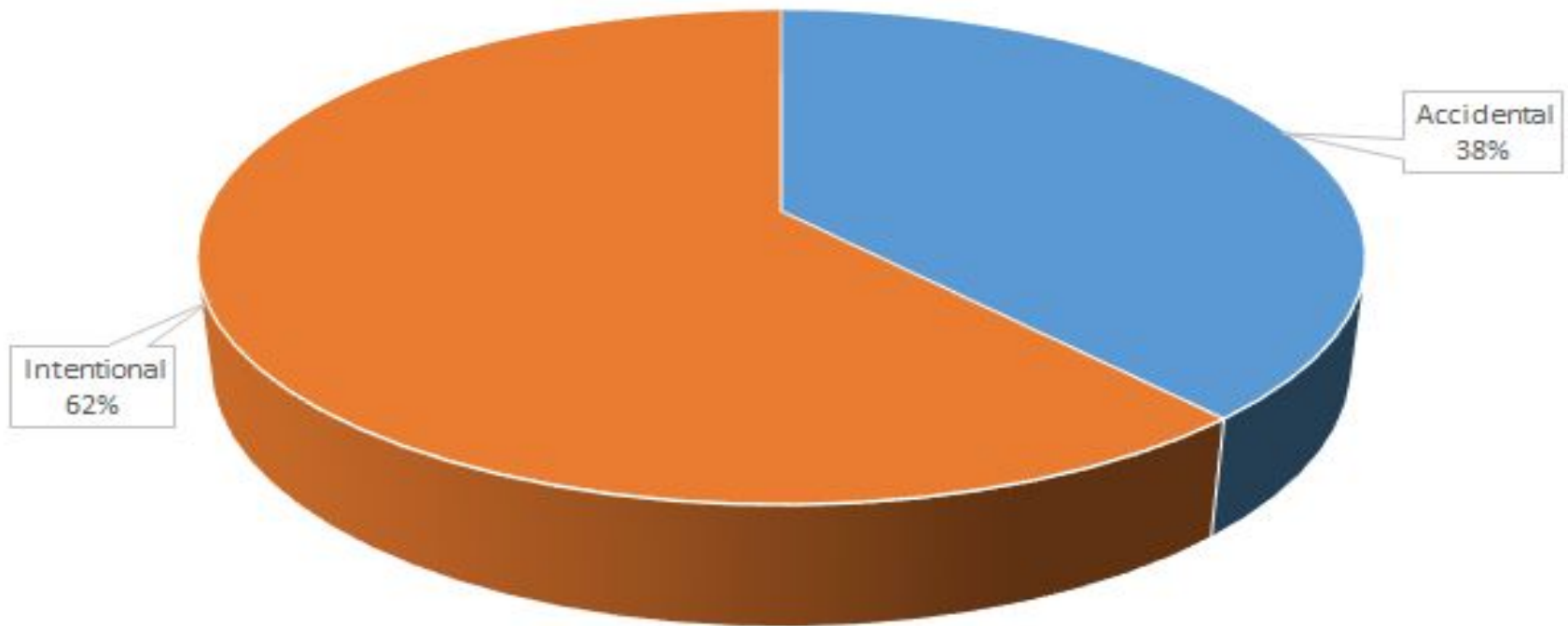
Provision of
Information

Rolling
Stock

Door Reopening



Observed Door Reopening Cause



Solving the Problem



A CONCLUSIONS OVERVIEW



OBJECTIVE 3

Propose Solutions



Station
Platforms

Benches

Visability

Information
Display

Updated
and New
Signage

Platform
Floor Lines

Employees

Platform
Attendants

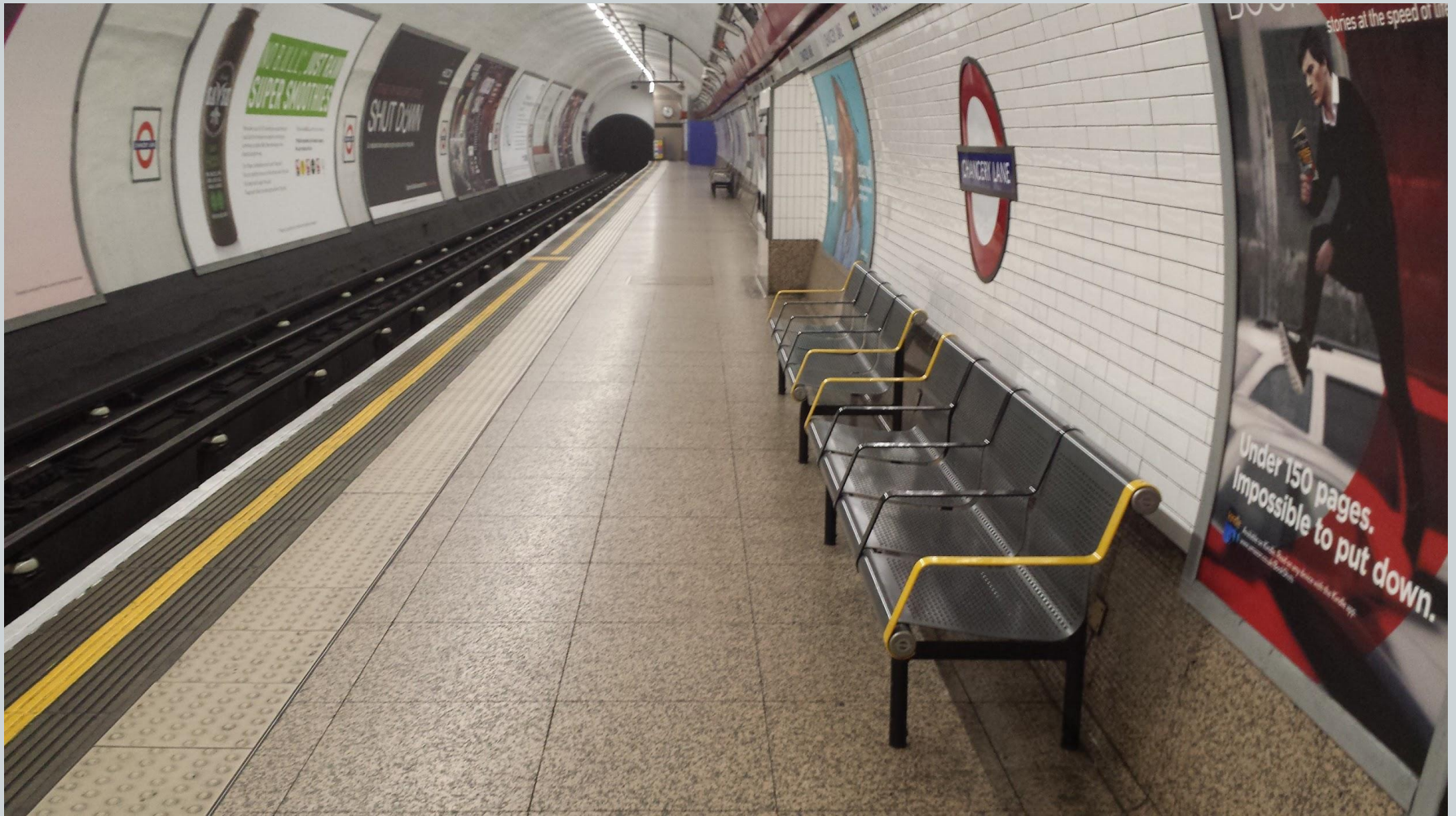
Rolling
Stock

Handles

Directional
Train Doors

New Trains

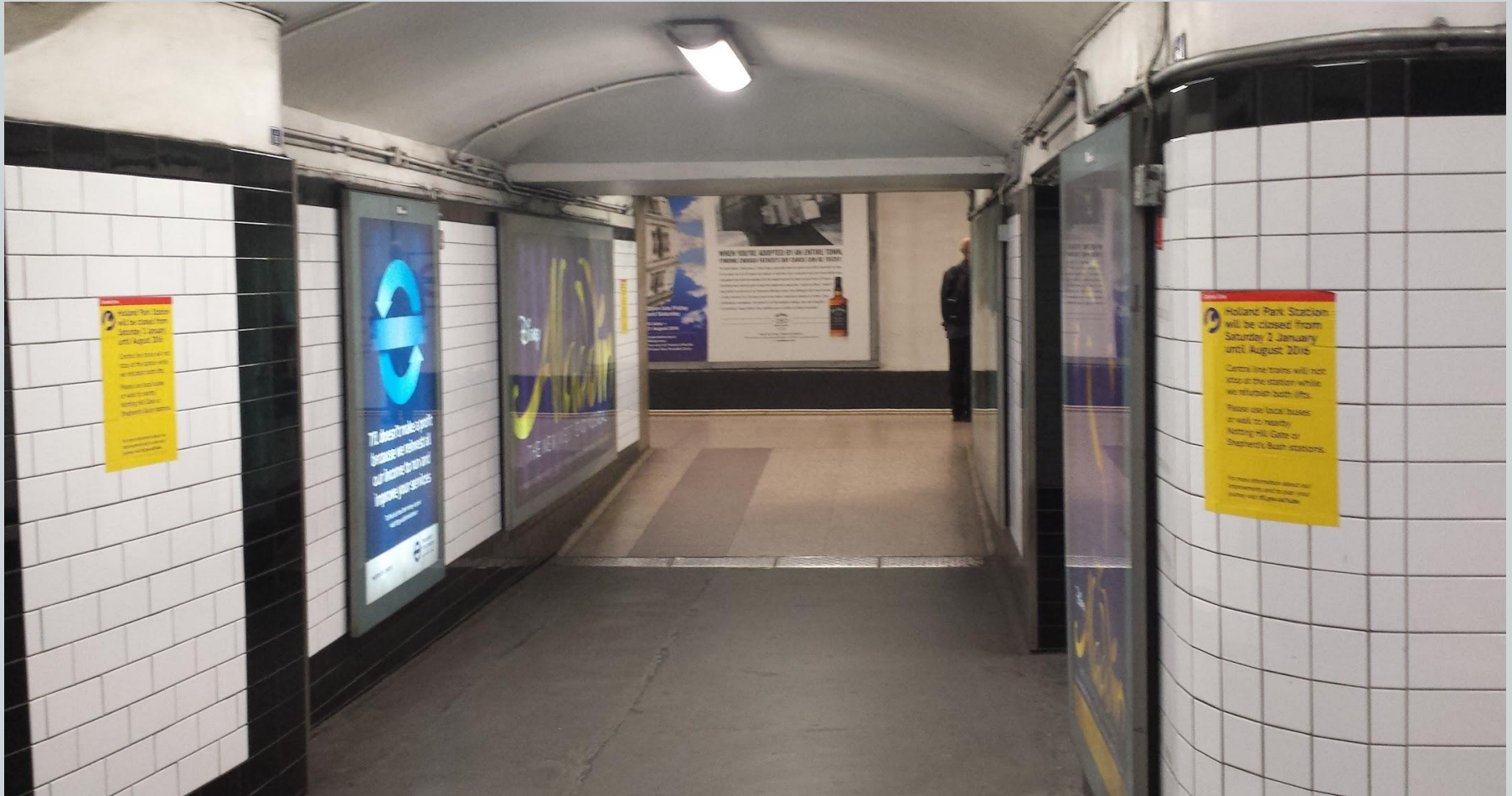
Platform Benches



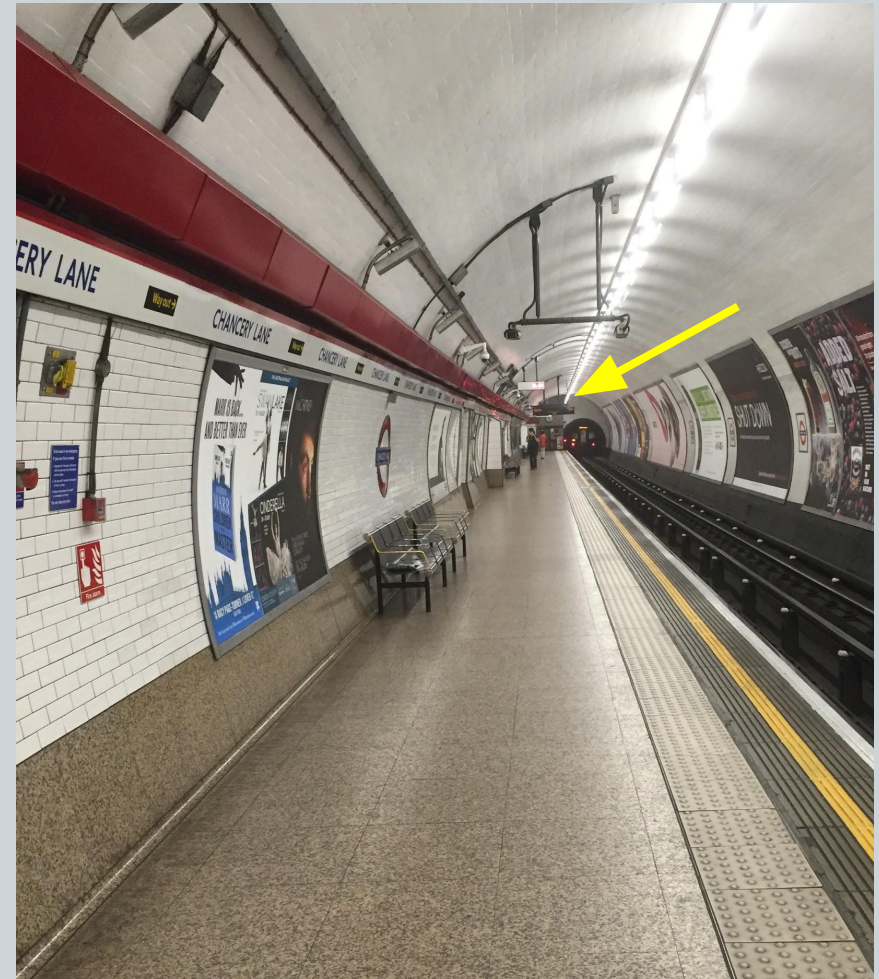
Platform Benches



Reduce Train Visibility



Signage Placement



Passenger Information Display



Passenger Information Display



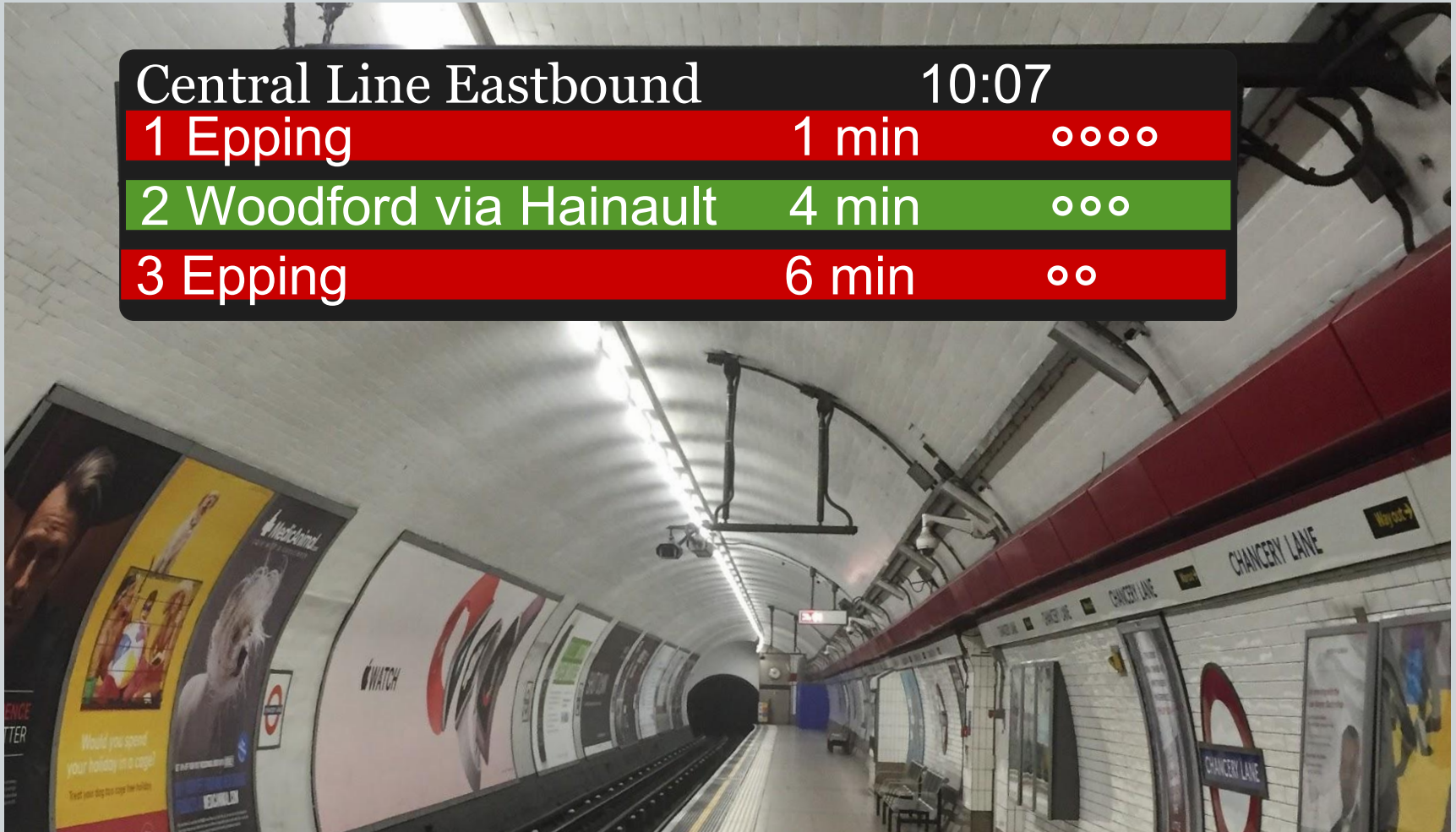
Central Line Eastbound		10:07
1 Epping	1 min	6 min
2 Woodford via Hainault	4 min	10 min
3 Epping	6 min	14 min



Passenger Information Display



Central Line Eastbound		10:07
1 Epping	1 min	oooo
2 Woodford via Hainault	4 min	ooo
3 Epping	6 min	oo



Additional Signs



ALL TRAINS GO TO STRATFORD

Platform Floor Lines



Way Out Indicators



No Standing Zone Lines



Platform Attendants



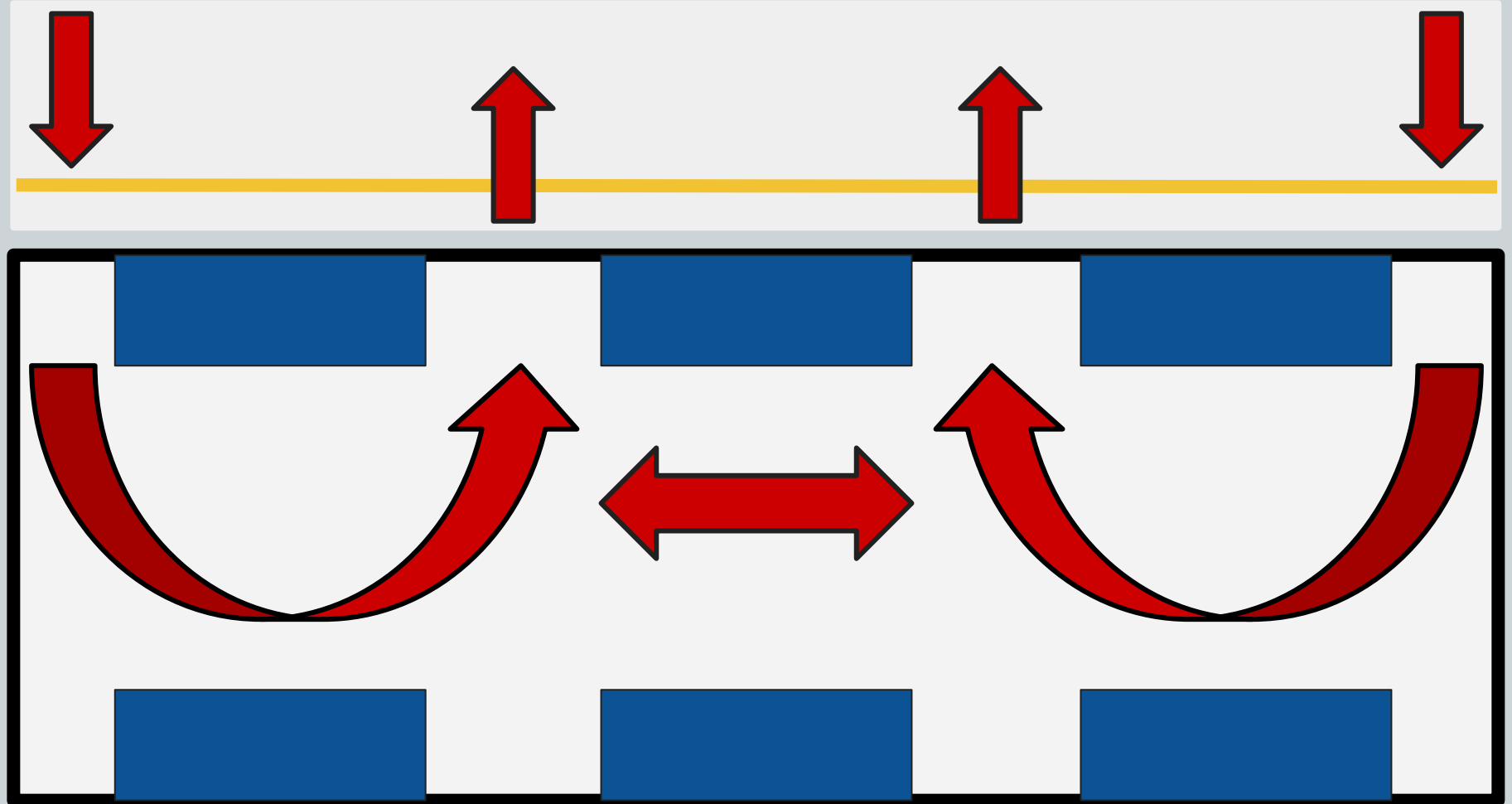
Handle Placement



Handle Placement



Single Direction Doors



New Rolling Stock



Recommendations



Central Line Improvements

Testing
Solutions



Technical
Aspects



Tourist
Information



Recommendations



Station Layouts

Leytonstone



Mile End &
Stratford



Bank &
Monument



Recommendations



Future IQP Projects



**Transport
for London**



National Rail



21 June 2016

Reducing Dwell Time: **London Underground Central Line**



Questions?

JAKE KELLEY ♦ DANNY KO

LAURIE MAZZA ♦ SAMANTHA ROBINSON

References (Pictures)



Introduction

http://www.clipartpanda.com/clipart_images/class-north-america-48346252

<http://www.tubeprune.com/tube-surface-comp-reduced3.jpg>

https://www.petersons.com/college-search/worcester-polytechnic-institute-000_10000337.aspx

Background

<http://www.dailymail.co.uk/news/article-2552044/Londoners-face-tube-strike-chaos-underground-worker-pictured-sleeping-desk.html>

<http://www.wearethepractitioners.com/library/the-practitioner/2014/07/01/urbanization>

<http://cityroom.blogs.nytimes.com/2011/10/03/soon-i-will-mean-less-crowded-subway-officials-say/>

http://www.thetraininvain.com/2014_10_01_archive.html

http://inventorspot.com/articles/six_startling_scenes_overcrowded_6802

<https://tfl.gov.uk/cdn/static/cms/images/tube-map.gif>

[https://en.wikipedia.org/wiki/Central_line_\(London_Underground\)#/media/File:Central_line_%26_London_map.svg](https://en.wikipedia.org/wiki/Central_line_(London_Underground)#/media/File:Central_line_%26_London_map.svg)

<http://www.telegraph.co.uk/finance/property/buying-selling-moving/11780834/Revealed-the-most-in-demand-Tube-stop-for-house-buyers-isnt-even-in-London.html>

Methodology

http://www.toledoblade.com/image/2011/12/26/800x_b1_cCM_z/APTOPIX-Britain-Tube-Strike.jpg

<https://www.ianvisits.co.uk/blog/2015/07/12/3d-maps-of-every-underground-station-hijklm/>

<http://www.london-tube-map.info/central-line/>

<http://www.londonbusblinds.com/prodimages/ENAMEL22%20CCTV%20Cameras,%20Switchroom,%20No%20Access.jpg>

<https://www.flickr.com/photos/98587546@N00/15562702668>

<http://www.mirror.co.uk/news/uk-news/chancery-lane-smoking-bag-sparks-3722795>

References (Pictures)



<http://metro.co.uk/2015/11/25/the-decades-old-etiquette-of-keeping-right-on-tube-station-escalators-could-soon-be-over-5525856/>

http://news.bbc.co.uk/local/london/hi/people_and_places/newsid_8744000/8744620.stm

Data & Analysis

<http://www.telegraph.co.uk/news/uknews/road-and-rail-transport/11782636/How-much-do-tube-drivers-get-paid-and-why-are-they-striking-now.html>

<http://www.elker.com/clipart-notebook-paper.html>

Conclusion

<http://www.cityam.com/234319/tfl-tube-strike-february-2016-rmt-calls-off-maintenance-workers-strike-on-friday>

http://www.alibaba.com/product-detail/ZTZY9030-folding-seat-tour-bus-seats_581744453.html

<https://www.theguardian.com/uk-news/2015/dec/25/london-underground-staff-use-fake-names-id-badges-security>

<http://www.streetlightonline.co.uk/Tube/centralgallery1.htm>

<http://www.railwaygazette.com/news/urban/single-view/view/new-tube-for-london-invitations-to-tender-issued.html>

<http://www.telegraph.co.uk/news/2016/04/18/what-really-happened-when-tfl-forced-commuters-to-stand-not-walk/>

<http://www.londonreconnections.com/2015/blue-monday-why-the-victoria-line-to-walthamstow-is-closed/>

<http://www.cambridgeincolour.com/forums/thread22505.htm>

<https://www.yelp.co.uk/biz/leytonstone-london-underground-station-london>

<http://www.dailymail.co.uk/news/article-2553900/Passengers-trapped-platform.html>

http://london-underground.blogspot.co.uk/2012_03_01_london-underground_archive.html

<http://www.indianlink.com.au/would-modes-of-transport-kindly-behave-themselves/>

<https://sheilapontis.wordpress.com/2013/01/07/mind-the-gap/>

<http://group.canarywharf.com/media/press-releases/major-breakthrough-for-crossrail-as-tunnelling-machine-enters-canary-wharf-station-5/>

References



- Bentley, G. and Ehrenberg, B. (2015, January 7). London Underground tube delays worst on central, Jubilee, Victoria Lines as overcrowding strains network. *City A.M.* Retrieved from: <http://www.cityam.com/206622/london-underground-tube-delays-worst-central-jubilee-and-victoria-lines-overcrowding-strains>
- Karekla, X. and Tyler, N. (2012, July). Reduced dwell times resulting from train–platform improvements: The costs and benefits of improving passenger accessibility to Metro trains. *Transportation Planning and Technology*, 35 (5), 525-543. doi: 10.1080/03081060.2012.693267
- MasterCard. (2016). Number of international overnight visitors in the most popular city destinations worldwide in 2015. In *Statista - The Statistics Portal*. Retrieved from <http://www.statista.com/statistics/310355/overnight-visitors-to-top-city-destinations-worldwide/>.
- Morton, Jill. (2010). Why Color Matters. *Colorcom*. Retrieved from: <http://www.colorcom.com/research/why-color-matters>
- Office for National Statistics (UK). (2012). Forecasted regional population of London (UK) from 2012 to 2037 (in 1,000). *Statista - The Statistics Portal*. Retrieved from: <http://www.statista.com/statistics/379035/london-population-forecast/>.

References



Parry, R. (2008). Train Design Guide. *Transport for London*.

Transport for London. (2014). *Fit for the Future* [Brochure]. London

Transport for London. (2016). Facts and Figures. *Transport for London*. Retrieved from: <https://tfl.gov.uk/corporate/about-tfl/what-we-do/london-underground/facts-and-figures>

Transport for London (2016). Underground services performance. *Transport for London*. Retrieved from: <https://tfl.gov.uk/corporate/publications-and-reports/underground-services-performance>

Transport for London (2016). Tube. *Transport for London*. Retrieved from: <https://tfl.gov.uk/maps/track/tube>

Wright, E. (2015). Scope of Works for Central Line Dwell Time Study. Email, 2 Dec. 2015.

***Heartbeat database**